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U. S. DEPARTMENT OF AGRICULTURE.
WEATHER BUREAU.

PROCEEDINGS OF THE SECOND CONVENTION OF WEATHER BUREAU OFFICIALS

HELD AT

MILWAUKEE, WIS., AUGUST 27, 28, 29, 1901.

Edited under the direction of WILLIS L. MOORE, Chief U. S. Weather Bureau.

BY

JAMES BERRY,
Secretary of the Convention,

AND

W. F. R. PHILLIPS.

WASHINGTON:
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LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Weather Bureau,
Washington, D. C., March 19, 1902.

Hon. James Wilson,
Secretary of Agriculture.

Sir: I have the honor to transmit herewith report of the second convention of Weather Bureau officials, held at Milwaukee, Wis., August 27, 28, and 29, 1901, recommending its publication as a bulletin of the Weather Bureau, the edition to be 5,000 copies.

This and the first convention (held at Omaha) have demonstrated their usefulness by affording exceptional opportunity for exchange of views and discussion of methods and means for advancing the work of the Weather Bureau.

This report contains many papers that will prove of interest and of practical value to the members of the Weather Bureau, as well as to its large corps of voluntary observers, forecast displaymen, and climate and crop correspondents. It also contains a number of papers that will prove of value to scientific meteorology.

Very respectfully,

Willis L. Moore,
Chief United States Weather Bureau.

Approved:

James Wilson,
Secretary of Agriculture.

PROCEEDINGS OF THE SECOND CONVENTION OF WEATHER BUREAU OFFICIALS.

MINUTES.

The second triennial convention of United States Weather Bureau officials at Milwaukee, Wis., August 27, 28, and 29, 1901, was the largest and most successful yet held. The attendance of 100 included the Secretary of Agriculture, the Chief of the Weather Bureau, members of his scientific staff, official forecasters, chiefs of divisions of the central office, and the officials in charge of the principal stations throughout the country.

The following members were in attendance:

Cleveland Abbe, Washington.
R. G. Allen, Ithaca.
A. McC. Ashley, Washington.
H. C. Bate, Nashville.
J. W. Bauer, Columbia, S. C.
W. S. Belden, Vicksburg.
James Berry, Washington.
F. H. Bigelow, Washington.
S. M. Blandford, Boise.
M. E. Blystone, Springfield, Ill.
W. T. Blythe, Indianapolis.
E. H. Bowie, Galveston.
H. B. Boyer, Savannah.
Al. Brand, Atlantic City.
F. H. Brandenburg, Denver.
B. H. Bronson, Bismarck.
E. B. Calvert, Washington.
F. P. Chaffee, Montgomery.
G. M. Chappel, Des Moines.
J. P. Church, Washington.
F. H. Clarke, Scranton.
F. M. Cleaver, Washington.
I. M. Cline, New Orleans.
Joseph L. Cline, Sandusky.
N. B. Conger, Detroit.
Patrick Connor, Kansas City.
H. J. Cox, Chicago.
W. S. Currier, Toledo.
D. Cuthbertson, Buffalo.
R. H. Dean, La Crosse.
L. A. Denson, Meridian.
W. M. Dudley, Mobile.
E. C. Easton, Baltimore.
E. H. Emery, New York.
S. C. Emery, Memphis.
E. A. Evans, Richmond.
W. H. Fallon, Grand Haven.
O. L. Fassig, Baltimore.
G. E. Franklin, Los Angeles.
W. M. Fulton, Knoxville.
E. B. Garriott, Washington.
E. J. Glass, Helena.
S. W. Glenn, Huron.
A. E. Hackett, Columbia, Mo.
R. M. Hardinge, Santa Fe.
R. B. Harkness, Houghton.
M. W. Hayes, Havana.
J. S. Hazen, Springfield, Mo.
A. J. Henry, Washington.
H. B. Hersey, Louisville.
R. J. Hyatt, St. Louis.
T. B. Jennings, Topeka.
L. N. Jesunofsky, Charleston.
E. P. Jones, Portland, Me.
James Kenealy, Cleveland.
C. E. Linney, Chicago.
G. A. Loveland, Lincoln.
P. F. Lyons, St. Paul.
J. B. Marbury, Atlanta.
C. F. Marvin, Washington.
A. G. McAdie, San Francisco.
E. W. McGann, New Brunswick.
A. J. Mitchell, Jacksonville.
Willis L. Moore, Washington.
S. L. Mosby, Ithaca.
L. H. Murdoch, Salt Lake City.
G. H. Noyes, Boston.
G. B. Oberholzer, Charlotte.
T. S. Outram, Minneapolis.
W. S. Palmer, Cheyenne.
H. R. Patrick, Marquette.
W. F. R. Phillips, Washington.
L. M. Pindell, Chattanooga.
U. G. Purssell, Sioux City.
George Reeder, Corpus Christi.
E. B. Richards, Little Rock.
H. W. Richardson, Duluth.
O. W. Roberts, Yankton.
J. H. Robinson, Washington.
G. N. Salisbury, Seattle.
C. F. Schneider, Lansing.
L. G. Schultz, Fort Worth.
J. M. Sherier, Davenport.
W. U. Simons, Key West.
A. F. Sims, Albany.
J. H. Smith, Carson City.
J. Warren Smith, Columbus.
P. H. Smyth, Cairo.
O. D. Stewart, Grand Junction.
C. M. Strong, Oklahoma.
L. M. Tarr, New Haven.
G. T. Todd, Dodge.
T. F. Townsend, Philadelphia.
C. F. von Herrmann, Raleigh.
B. L. Waldron, Columbus.
F. J. Walz, Chicago.
L. A. Welsh, Omaha.
H. E. Williams, Washington.
W. M. Wilson, Milwaukee.
A. B. Wollaber, Portland, Oreg.

The following guests and visitors were in attendance at one or more of its sessions: Mr. George McCurdy, Chicago, Ill.; Mr. Charles B. Murray, Cincinnati, Ohio; Mr. La Verne W. Noyes, Chicago, Ill.; Rev. Father F. L. Odenbach, Cleveland, Ohio; Mr. E. R. Sharwood, Philadelphia, Pa.; Mr. John Thorson, Milwaukee, Wis.; Rev. Judson Titsworth, Milwaukee, Wis.; Mr. Harvey M. Watts, Philadelphia, Pa.; Hon. James Wilson, Ames, Iowa; Mr. H. Helm Clayton, Bluehill, Mass.; Misses Mary and Julia Lapham, daughters of the late Dr. I. A. Lapham, Milwaukee, Wis.

FIRST SESSION.

Dr. W. M. Wilson, of the local United States Weather Bureau office, welcomed the convention as follows:

Mr. President and Gentlemen of this Convention: It is with unalloyed pleasure that I greet you this morning. I have looked forward to this occasion for several months, always with pride and pleasure, but not always without anxiety—with pride and pleasure in being the local representative of this magnificent body of my coworkers; with anxiety lest something be overlooked which might contribute to the success of this convention or to your personal pleasure and comfort while you are among us. There is one point, however, upon which I am sensitive. I have been telling the people of Milwaukee, during the past few months, so many wonderful things about you—for all of which I hope I am not to be held too strictly to account—that I am a trifle uneasy in my mind as to what my reputation will be after the convention closes. [Laughter.] I hope, however, that by stretching a point or two you may be able to measure up to all the promises I have made concerning you. I am not authorized to speak for the people of Milwaukee, but I feel competent to offer you a little advice, based upon my residence here during the last six or seven years. In the first place, you will please the people of Milwaukee if you make yourselves entirely at home. In the next place, if there is anything you want, and it is in sight, take it and use it, and ask to whom it belongs afterwards. If there is anything you want and it is not in sight, I would advise you to ring up Main 419, the office of the mayor of Milwaukee, the Hon David S. Rose. [Applause.]

Mayor Rose was formally introduced to the convention and addressed it as follows:

Gentlemen of the Convention: Dr. Wilson is a citizen of Milwaukee. We are perfectly familiar with his reputation, and were you as familiar with it as we are, you would not be surprised to know that he is liable to exaggerate sometimes. [Laughter.] I assure you that anything you may do will not create a false impression in the minds of the Milwaukee people. [Laughter.]

About fifteen years ago, when I became a citizen of Milwaukee, one of the first people to attract my attention was a slim-built, pale-faced, delicate, studious-looking young man, known to but a few of his closest neighbors and unknown to fame. Few who met him on the street with head down, apparently always in studious thought, would have even dreamed that in a few short years he would have attained to the proud distinction of being the Chief of the Government Weather Bureau. [Applause.] We have watched his course with pride, because we claim him as one of our own. But his career is not surprising to Milwaukee people, because Milwaukee is full of just such timber. [Applause.] To you who are strangers in the city perhaps it will be of interest to know in advance something of who we are and what we are. We welcome you with sincere pleasure; we welcome you as practical workers in a splendid cause. Your labor contributes to the building up of commerce and business, to the building up of cities, to aiding the people who are engaged in the practical pursuits of life. Milwaukee, with the best harbor on the great chain of lakes, with her splendid lake commerce and her wonderful freightage, watches the signals as they are displayed upon the local signal station and trusts them. The work so well begun by Mr. Moore long years ago gives us confidence in the Bureau, and the work so well begun by him has been carried on with fidelity and splendid ability by those who have succeeded him, especially by him who occupies the place of chief of our local office at the present time.

We have a population of upward of 300,000 thrifty, sturdy, progressive inhabitants. The city is a great manufacturing center. We produced last year upward of $175,000,000 worth of manufactured products. Our growth is of the sturdy kind, and rapid, too, because in the last census decade our percentage of growth was 39.54 per cent. We increased our population by upward of 85,000 inhabitants. Milwaukee undertakes to keep pace with her sister cities in the rapid march of progress. We appreciate the fact that it is the friction of individual competition that animates business, and that same spirit of competition that inspires individual effort is the strong lever that moves cities onward and upward. Our population is a cosmopolitan population—more cosmopolitan, perhaps, than that of any other large city of this Union, because we have represented here in our splendid citizenship every civilized nation on earth, all living together in perfect harmony, seeking to accomplish the greatest good for the greatest number. Our government is of the liberal kind, the kind that is exacted by a foreign-born citizenship: and while it is true that we act upon the principle of according the greatest liberty consistent with good order and good morals, it is likewise true that ours is the most orderly city upon this continent. Our percentage of crime is the lowest.

There is a popular fallacy in the minds of strangers who live remote from us that Milwaukee is given to the manufacture of but one special product. It is true that we do manufacture an exhilarating nectar, with which you have perhaps not yet become acquainted. You have now the opportunity. But while it is true that our brewing industry is a great one, it is likewise true that it pales into comparative insignificance when compared with other great manufacturing industries we possess, giving employment to upward of 85,000 operatives. I invite you, as you have the opportunity in the intermissions of business, to visit some of our public parks. Our park system is young in years, but old in beauty and attractiveness. We were confronted with the same question, the same important problem, as I esteem it, that comes to every city some time in the course of its existence, namely, whether it is better to establish one, or perhaps two, large parks or a number of small parks. Those who were clothed with the responsibility, in the exercise of what I esteem to be most excellent judgment, decided upon the latter plan. As a result, we have a large number of small parks distributed throughout our territory, thus affording to the poorer classes of our city opportunities enjoyed only by the rich in the large cities of the country. We have no tenement houses in Milwaukee; on the contrary, you find the humble cottage of the laboring man and the more pretentious residence of our artisans out in the free air of the suburbs. There they rear their children to strong and sturdy manhood. Our school system is a part of the old Badger State that places her in the foremost rank in educational matters. We appropriate upward of $750,000 annually for the maintenance of our public schools. We carry the elements of common-school education and lay them at the thresholds of all our people. Our splendid public library and museum building, recently erected at a cost to the city of $750,000, is one of the finest educational institutions in our State, beautiful in architecture, well equipped in every department. There you will find the children of our city, afternoon and evening, pursuing the studies and cultivating themselves for the splendid citizenship of which they are to become a part.

In behalf of all our people, I extend to you a most cordial greeting and a most hearty welcome. I trust that your labors here will be profitable to you, and that incidentally you will find opportunities for pleasure, so that when you return to your respective homes you will carry only happy memories of your visit to the Cream City. [Applause.]

Professor Moore. Mr. Mayor of Milwaukee, I know something of the city of Milwaukee myself. I have lived here long enough to imbibe some broad principles of charity and good-fellowship that were instilled into me by association with its people. I remember a lawyer who at the time I lived here was not extensively known. He has since that time been twice elected mayor of this great city—twice received the suffrages of his fellow-citizens. It is a magnificent city and a magnificent people. [Applause.] Mr. Mayor, I shall not make any extended remarks, though I would like to talk to you as long as you have talked to us; but I know you have another engagement, and I will end by simply thanking you in behalf of this convention, and through you the people of the city, for the courtesies which they have extended to us.

President Willis L. Moore delivered his address (printed elsewhere in full) and formally declared the convention open.

Prof. Frank H. Bigelow read a paper on "Higher meteorology."

Mr. W. M. Fulton and Prof. Alex. G. McAdie read papers on "Supplying employees with apparatus for carrying on original scientific investigations under certain conditions."

Mr. L. G. Schultz read a paper on "Study of polarization of light with reference to weather conditions." Discussed by Professors Abbe and Moore.

Prof. Alex. G. McAdie read a paper on "Fog studies." Discussed by Professors Bigelow and Moore, Mr. Clayton, and Rev. Father Odenbach.

Mr. A. McC. Ashley, for Mr. D. J. Carroll, unavoidably absent, read "The personnel of the station force."

Mr. E. J. Glass read a paper on "Chinook winds." Discussed by Mr. H. Helm Clayton.

President Moore, in introducing Mr. Harvey M. Watts, of the Philadelphia Press, said:

One of the most important parts of our work is getting information before the people in the press in a thoroughly intelligent way. Our difficulty in doing this is not the fault of the press, because the press is universally generous toward the weather service. They cooperate to the best of their ability in putting our information fairly before the people. They make it a leading feature of some of the most prominent parts of their publications. But there is a great ignorance of what should be general meteorological information. There are some few thoroughly scientific editorial writers who are giving thought to meteorological problems and who are really doing more to educate the people than the text-books, because they have such a tremendous constituency. One of these writers is Mr. Watts. He has done splendid work as a newspaper writer in furthering the cause of the science of meteorology and in striving for correct nomenclature in the discussion of meteorological problems.

Mr. Watts read a paper on "The forecaster and the newspaper."

Mr. M. W. Hayes read a paper on "Value of the climate and crop and storm warning services of the Weather Bureau to the industries of Cuba and other islands of the West Indies."

Mr. G. H. Noyes read a paper on "Value of the climate and crop and storm warning services of the Weather Bureau to the industries of Porto Rico." Discussed by Mr. J. L. Cline.

Dr. O. L. Fassig read a paper on "The westward movement of a daily barometric wave across the North American continent in July." Discussed by Professors Moore and Bigelow and Mr. Clayton.

Mr. H. Helm Clayton, for Mr. A. L. Rotch, read a paper on "A method for the systematic exploration of the atmosphere by means of kites."

The following papers were read by title: "A marked rise in the normal Baltimore temperature curve for May," by Dr. O. L. Fassig; "Advent of spring," by C. F. von Herrmann; "Lightning records and their utility in forecasting thunderstorms," by James Kenealy; "Career the Weather Bureau offers to young men," by Roscoe Nunn.

President Moore then acknowledged the presence of Misses Mary and Julia Lapham as guests of the convention, as follows:

At the opening of this convention we paid our compliments to Dr. Increase A. Lapham. Surely the Weather Bureau recognizes the great debt of gratitude it owes to that great student and scientist, that patient worker in natural science, who gave so much to the world and for whom the world has done so little. The convention, through me, has extended an invitation to Misses Mary and Julia Lapham, daughters of Dr. Lapham, and now I extend to them the warm greetings of this convention. We are pleased that they have honored us with their attendance."

The convention adjourned at 1 p. m. to reconvene at 2.30 p. m.

SECOND SESSION.

The convention met at 2.43 p. m.

Dr. Phillips delivered his address as chairman of section 2.

Mr. G. N. Salisbury read a paper on "Systematic study of meteorology on stations."

Mr. F. P. Chaffee read a paper on "Meteorology in the public schools: How much should be attempted? Methods of teaching." Discussed by Messrs. Blandford, Oberholzer, Watts, Clark, and Jennings, Professor Abbe, Messrs. J. Warren Smith, Hackett, Connor, and the chairman.

Mr. G. A. Loveland read a paper on "Meteorology in colleges: To what extent is it taught at present? Should it be offered as an undergraduate or as a post-graduate course?" Discussed by Dr. Fassig and Professor Abbe.

Mr. J. Warren Smith read a paper on "Popular lectures on meteorology, including lectures to farmers' institutes, social gatherings, societies, etc.: Are such lectures valuable in proportion to time given? What should be the general character of such lectures?" Discussed by Messrs. McGann, Hazen, Professor Marvin, Messrs. Chaffee, Mitchell, Professor Moore, Dr. Cline, Dr. Fassig, Professor Abbe, Messrs. Richards and Berry.

Mr. C. E. Linney read a paper on "Climate and vegetation: Relation and influence of climatic elements and factors (temperature, rainfall, sunshine, etc.) to vegetable growth and development." Discussed by Mr. J. Warren Smith.

Dr. W. M. Wilson read a paper on "Climate and man; with special regard to climate and climatic elements as curative or causative agencies of disease, etc."

Dr. I. M. Cline submitted a brief "Synopsis of a course of lectures in medical climatology."

Mr. R. H. Dean read a paper on "Influence of climate on animal life."

The following paper was read by title: "Climate and thought," by Mr. E. C. Easton.

The convention adjourned at 5.55 p. m.

THIRD SESSION.

The convention met at 9.50 a. m., 28th.

Professor Garriott, as chairman of section 3, delivered his address.

Mr. F. J. Walz read a paper on "The relation between general and local forecasts." Discussed by Mr. E. H. Bowie.

In the temporary absence of Professor Cox, Mr. E. B. Calvert read a paper by the former on the questions, "Should the verifying change of temperature be smaller and should not the terms 'slightly warmer' or 'slightly cooler' be credited?" Discussed by Messrs. E. H. Emery, D. Cuthbertson, A. J. Mitchell, N. B. Conger, and Patrick Connor.

Professor Henry read a paper on the question, "Should not temperature forecasts be verified by the maximum and minimum readings?" Discussed by Professor McAdie and Mr. L. M. Pindell.

Mr. F. H. Brandenburg read a paper on "Facilities for systematic study of corresponding weather types." Discussed by Professor Moore.

Mr. F. P. Chaffee read a paper on "Importance of the synopsis preceding the forecast, and how to make the synopsis instructive to the public." Discussed by Mr. R. B. Harkness.

Upon motion of Professor Henry, Mr. Harvey M. Watts was granted permission to read a paper on "The Public *v.* The Forecaster." Favorably commented upon by Professors Moore and Abbe, and upon motion of the latter a vote of thanks was extended Mr. Watts.

Mr. J. H. Robinson read a paper on "The telegraph and weather service."

Mr. P. H. Smyth read a paper on "Importance of river-stage forecasts of the Mississippi and Ohio rivers and tributaries in periods of low water." Discussed by Mr. L. M. Pindell.

Mr. H. B. Boyer read a paper on "Weather forecasts and the public."

The following papers were read by title: "Value of the dew-point in forecasting weather under certain conditions," by Peter Wood; "The double observation as a means of improving forecasts," by Lee A. Denson; "Substitution of acetylene gas for oil in storm-warning lanterns," by H. W. Richardson; "Verification of forecasts," by J. B. Marbury; "Forecasting for rivers of small drainage area," by Charles F. von Herrmann; "Should temperature forecasts be verified by maximum and minimum readings?" by P. F. Lyons.

The reading of the preceding papers by title concluded, at 12 m., section 3 of the programme, and without adjournment the convention proceeded with section 4.

Section 4.

Prof. A. J. Henry, chairman of section 4, delivered his address.

Mr. E. A. Evans read a paper on "Meteorological and other forms and reports: Should they be simplified; are other modifications desirable?" Discussed by Mr. E. C. Easton.

Mr. J. W. Bauer read a paper on "The examination of monthly meteorological reports of voluntary observers: Is it desirable to report back to the voluntary observer the errors and irregularities discovered in his report?"

Mr. S. C. Emery read a paper on "The best means of preserving records for reference and study." Discussed by Professor Henry.

The following papers were read by title: "Necessity for binding and otherwise preserving the publications of climate and crop sections," by W. S. Belden; "Use of collected data," by W. S. Palmer; "Records in court," by C. E. Linney.

At 1 p. m. the convention adjourned to meet at 2 p. m.

FOURTH SESSION.

Section 5.

The fourth session was called to order at 2.15 p. m. Address by chairman, Mr. James Berry.

The first paper read was, "Should the monthly report of the climate and crop sections contain only original matter?" by Mr. G. A. Loveland.

Mr. T. B. Jennings read for Mr. S. W. Glenn, who was indisposed, a paper on "Should the remarks of climate and crop correspondents be published in the weekly bulletins?" Discussed by Mr. C. F. von Herrmann.

Mr. M. E. Blystone read a paper on "Is it advisable to distribute the night forecasts by the rural free delivery?" Discussed by Mr. C. F. Schneider.

Mr. S. L. Mosby read for Mr. R. G. Allen, who was indisposed, a paper on "How many climate and crop correspondents are required to meet fully the needs of the Bureau in its climate and crop service?" Discussed by Mr. A. E. Hackett, Mr. James Berry, and Mr. J. P. Church.

Mr. J. Warren Smith read a paper on "Phenological data."

Mr. C. F. von Herrmann read a paper on "Climatological studies, with reference to the crops of the several sections."

Dr. O. L. Fassig read a paper on "Maryland climatological studies." Discussed by Mr. F. J. Walz.

Mr. W. T. Blythe read a paper on "Methods of saving time in the distribution of forecasts." Discussed by Mr. C. E. Linney.

"Forecast cards on street cars" was the subject of a paper by Mr. N. B. Conger. Discussed by Messrs. L. M. Pindell and J. B. Marbury.

A paper on "Weather symbols on rural free delivery wagons" was read by Mr. L. M. Pindell.

Dr. Phillips moved that, as it was understood that several members had prepared papers which could not be entered on the programme, such members be permitted, under the circumstances, to deposit their papers with the secretary, and that these papers be regarded as read by title.

Adopted.

Notice was given that Mr. John Thorsen had courteously granted permission to all members of the convention and the ladies accompanying them to visit the art gallery at any time without charge.

A paper on "Climatology of Florida with regard to crops," by A. J. Mitchell, was read by title.

The fifth section was concluded at 4.55 p. m., and the convention immediately proceeded with section 6 of the programme.

Section 6.

Address by Prof. Charles F. Marvin, chairman.

Dr. O. L. Fassig read a paper descriptive of a "Device for automatically recording beginning and ending of light precipitation." Discussed by Prof. C. F. Marvin and G. R. Oberholzer.

Mr. T. S. Outram read a paper on the question, "Is exposure at Weather Bureau stations for all instruments satisfactory?"

Mr. A. F. Sims read a paper on "Suburban observatories."

Mr. G. R. Oberholzer read a paper on the following subject: "The maximum and minimum thermometers are too fragile; can not effective protection be devised without impairing sensitiveness; should not aluminum scales be discarded?" Discussed by Mr. P. F. Lyons and Prof. C. F. Marvin.

Mr. A. B. Wollaber read a paper on the question, "Should not thermographs be furnished to voluntary observers, the records to be kept at section centers?"

Mr. W. M. Fulton read a paper on "The introduction of automatically recording river gages."

A paper on the subject of "River gages in the Upper Mississippi Valley," by Mr. W. W. Carlisle, was read by title. This concluded section 6 of the programme, the convention adjourning at 6.15 p. m. to meet at 10 a. m., August 29.

At 8 p. m., in the convention hall, 30 selected lantern slides, giving fog views made at the United States Weather Bureau Observatory at Mount Tamalpais, Cal., were shown on screen by Mr. McAdie. These views were commented upon by Professors Abbe and Marvin, Dr. Fassig, and others.

FIFTH SESSION.

At this, the final session, presided over by Professor Moore, addresses (printed elsewhere in proceedings) were delivered by Messrs. B. W. Snow, of the Orange Judd Farmer; Charles B. Murray, editor of the Cincinnati Price Current; La Verne W. Noyes, Chicago; E. R. Sharwood, Philadelphia; Rev. Father Odenbach, St. Ignatius College, Cleveland; Messrs. A. W. Machen, superintendent free delivery service, Post-Office Department; H. M. Watts, Philadelphia Press, and Hon. James Wilson, Secretary of Agriculture.

Mr. Calvert introduced the following resolution, which was adopted:

Whereas the officials of the United States Weather Bureau, in convention assembled, this 29th day of August, 1901, are most highly appreciative of the uniform courtesy, cordiality, and liberality with which we have been received and entertained during our sojourn in the Cream City: Therefore, be it

Resolved, That the hearty and sincere thanks of this convention be extended to the citizens, to the press club, and to the press of the city of Milwaukee, to the officials of the Chicago and Northwestern Railroad, and to Dr. Wilford M. Wilson, our able representative, for the many courtesies that they have all so kindly extended to us, and for their indefatigable and successful efforts in arranging for our entertainment and comfort; and be it further

Resolved, That the secretary of this convention be instructed to send a copy of these resolutions to Mr. E. C. Wall, chairman of the citizens committee; to Mr. William A. Bowdish, president of the press club; to Mr. H. R. McCullough, third vice-president of the Chicago and Northwestern Railroad, and to Dr. Wilford M. Wilson, section director of the United States Weather Bureau.

Professor ABBE. Moved, that the convention requests the secretary of the meeting to address a letter to Mr. John W. Smith, of Boston, expressing sympathy with Mr. Smith in his bereavement and regret at his absence, occasioned by the death of his mother.

So ordered.

Mr. H. E. Williams, chief clerk of the Weather Bureau, in rising to move a resolution, spoke of the pleasure it had given him to meet, face to face, so many members of the Weather Bureau whom he had never seen before, as well as those with whom he was acquainted. For many years he had been in correspondence with them in connection with the business of the central office, and had learned to respect, admire, and love the spirit that animated them, the thorough devotion to duty, and the earnestness of purpose that they manifested, and which he had found to prevail throughout the membership of the Bureau. One of the most beneficial effects of these conventions, he thought, was the spirit of solidarity, comradeship, and mutual esteem that inevitably resulted from them. Mr. Williams then moved a vote of thanks to the proprietors of the Hotel Pfister for their more than common courtesy in affording unusual facilities to the convention, as well for the uniform politeness and attention of the employees of the house. This was unanimously adopted.

After brief remarks by Mr. Alexander G. McAdie, Mr. A. J. Mitchell, Professors Bigelow and Moore, the latter at 1 p. m. declared the convention adjourned sine die.

A banquet was given the members of the convention at the Hotel Pfister by the citizens of Milwaukee on the evening of the 29th.

Through the efforts of Dr. W. M. Wilson, the local Weather Bureau official, generously seconded by the citizens of Milwaukee, the arrangements for the convention were most complete, nothing having been left undone that would have contributed to its success. The sessions were held in the banquet hall of the Hotel Pfister, at which all the members of the convention were quartered. This proved of very material advantage in view of the length of the programme and limited time at the disposal of the convention, the business of which was completed in a very satisfactory manner within the three days allotted.

Through the very efficient services rendered by Mr. R. M. Reese, stenographer to the honorable Secretary of Agriculture, the proceedings of the convention were very fully and accurately reported.

GENERAL SECTION.

PRESIDENT'S ADDRESS.

Prof. WILLIS L. MOORE, *Washington, D. C.*

GENTLEMEN OF THE CONVENTION: It is not necessary for me to extend any welcome to you after the remarks of Dr. Wilson and the eloquent speech of the mayor of Milwaukee, but in opening this convention, which is the most auspicious of any we have held, it may be appropriate to give a few, brief reminiscences. I am down on the programme to deliver an address. I shall not do so. I wish simply to talk to you for a few moments, and then we shall proceed with the regular order of the program.

It is interesting to recall that in 1870 this weather service had its inception. It is also interesting to note that the appropriation at that time was $20,000, and that to-day the people of the United States spend nearly one million two hundred thousand dollars annually for this service, and are satisfied with the expenditure; for the service has not been compelled to petition anybody for its maintenance for many years. Congress has freely given us every dollar we have estimated for in the past four years. Away back in 1870, and prior to that time, there were a few indefatigable workers whose object was the creation of an institution that was finally to send to Milwaukee such a convention as this. Dr. Lapham, whom everyone in Milwaukee loved, was one of those earnest workers, gentle in his way and modest in his demeanor. He and our own Professor Abbe [applause], did more than any other two persons to create the present weather service. Redfield, Espey, Loomis, Maury, Coffin, and other scientists had demonstrated the theory of storms as we understand it to-day. Neither Lapham nor Abbe added materially to that theory, but Abbe collected observations of the weather in 1869, with the aid of the Cincinnati Chamber of Commerce and the Western Union Telegraph Company, and began making forecasts for the purpose of giving an example of what could be done. Lapham collected records of some 2,000 disasters on Lake Michigan, the majority of which would have been averted had there been a weather service. Lapham went to the National Board of Trade and there got resolutions. He made such a lucid argument with the facts that he presented that finally a Congressman from Wisconsin, Gen. Halbert E. Paine, introduced in the Congress a resolution appropriating the $20,000, to which I have just referred.

From that modest beginning has grown the weather service of to-day. It embraces an area from the north coast of South America to the remotest confines of Canadian habitation, and from the Atlantic to the Pacific. It is the greatest survey of atmospheric conditions ever presented to the eye of the forecaster, and if meteorology, in its weather predictions, comes to be an exact science it will be due to the

energy and liberality of the United States Government in presenting such a magnificent daily picture for the study of the meteorologist. If it ever comes to the time when we can forecast the character of the coming seasons, so that the farmer may conserve his energies and spend them to the most profitable advantage, it will be due to the scientific study of such a broad atmospheric picture as the United States daily presents. It will not be due to chance.

When we began the weather service there was but little attention paid to us, except by the funny paragrapher. We were abused and ridiculed sometimes; more often treated with good-natured jest. The old mariner laughed at us; he sailed in the face of the storm signals, and delighted to do it. It was a long time before we convinced him of our value; and in fact we did make a great may mistakes in those days, and it was a long time before we were entitled to the confidence of the marine interests. But to-day hardly a ship sails, the master of which does not take cognizance of the weather map, daily forecasts, and storm signals. Down in New Orleans, when the recent storm came in from the Gulf, our official issued warnings that the papers of New Orleans say reduced the wreckage on the open waters at least $1,000,000. He was able to say to Galveston what was just as valuable to it as the storm warning was to New Orleans, viz: "You need have no fear; this storm will go northward and not strike the Texas coast. Only don't let your vessels sail out into it." That reassured the Galveston people and prevented their being panic-stricken.

I wish now briefly to refer to some important innovations that have taken place as a result of our convention at Omaha. New instrumental equipments have been placed at nearly all weather stations, so that nearly every observatory to-day is equipped with standard self-recording apparatus, whereas before but few even of our first-class stations had such adequate apparatus. We have erected at more than one-half the marine ports tall steel towers for the display of marine warnings, where before the warnings were displayed from anything to which a lantern could be tied. We have experimented to determine the most powerful lantern we could make that would be suitable for our use. We have inaugurated in the lake region what we call the lake marine service, with headquarters at Detroit, and we have made a study of the fog areas, so that at different seasons of the year the mariner may know on what portions of the different lakes he will meet the greatest percentage of fogginess. It was simply the establishment of the normal, that is all; but, by collecting the records from many vessels, we are able to say where, during certain seasons, there will probably be encountered the greatest amount of fog. The extension of the forecast system has been important. By cooperation with Mexico we now exchange observations with that country. By an extension of the service as an incident of the war with Spain we now have a service that covers the West Indies and surrounds the Gulf of Mexico. By a recent arrangement with the English meteorological office we get daily observations from the west coast of Europe. By the completion of the German cable from Lisbon across to the Azores and thence to New York we get observations from the Azores which are highly valuable in making warnings for the guidance of transoceanic steamers. The extension of the marine part of our work has resulted in enabling our forecasters to make fairly accurate ocean forecasts for outgoing steamers. We have to interpolate a little for the pressure of the North Atlantic, but it is found that our estimate is highly valuable to commerce and is accurately made. Most of the

things that I have referred to are important innovations that the marine interests have been seeking for years, and we are glad they have been obtained. Many other things that were discussed at our Omaha convention, as you know, have been incorporated in the weather service. I think the most profitable instruction I have ever received as chief of this service came from listening to your discussions at that convention three years ago. This is a coming together of supervising officials. One rubs up against another, gathers his ideas, takes them home, and applies them to his own work. It is a sort of clearing house for weather ideas.

One of the last and most important innovations in the weather service has been accomplished through the cooperation of Mr. Machen, Superintendent of the Rural Free-Delivery Service. We have had the hearty cooperation of the Post-Office Department, and to-day the mail carriers going out into the rural districts carry with them little slips containing the daily forecasts, and Mr. Machen finds it one of the most popular features of the rural free delivery. This part of our work will be greatly extended in the future.

There is another innovation that I hope to have made. I have not yet presented it to the Secretary of Agriculture, but I believe he will give it his approval, as he has always shown a disposition to favor anything that means help to the Weather Bureau. That is the construction of individual observatories in every city where we have a station. So far Congress has freely given us money to build separate meteorological observatories at isolated places on our various coasts. We are constructing six this year. I propose to place the matter before Secretary Wilson, so that he may place it before Congress, with a view to completing a few buildings each year, so that in a city like Milwaukee there would be erected a Weather Bureau building that would be in fact a Weather Bureau observatory. I believe that Congress will approve this.

One word about the discipline of the service and I am through. I think this convention, as I look over the faces of those present, speaks for itself of the merit system. It is the intention of the central office that only men of tried capacity, men who possess both ability and good character, shall be selected for the responsible positions of the weather service. Secretary Wilson has exacted of me only one condition in the making of recommendations to him for preferment in the service, and that is that my recommendations shall be fairly made. It has been my honest endeavor to place before him only the names of the men who were best fitted and most entitled to advancement when promotions were to be made. I have tried to discharge this duty righteously. I may have made errors. I may not, at times, have satisfied some, but I believe that I have satisfied the majority, for I can truthfully say that there has never been a preferment in the weather service since I have been Chief of the Bureau in which any consideration entered except the welfare of the public service and the merit of the official. As an instance, I may cite the fact that last winter Congress created an additional professor and three additional national forecasters. Now, that act became law the latter part of January or the first of February. I did not make the nominations to the Secretary until the 1st of June, and during that interval there was not a letter or personal application received from any person asking for any of these places. There was no intercession on the part of outside influences in behalf of any man in the service, and I think that fact is the strongest evidence that our people are

willing to rest their cases with the central office and allow it to select the men for important commissions unhampered by selfish intercessions. [Applause.]

HIGHER METEOROLOGY IN THE UNITED STATES WEATHER BUREAU.

By Prof. Frank H. Bigelow, *Washington, D. C.*

Such phrases as the "higher meteorology" are of very doubtful value, for they are, in fact, taken out of a cheap vocabulary which passes current for a time among people, while their view of things is limited to a small horizon. A thousand-dollar note is not higher money than a dollar; they should be equally good currency. A true fact is sound knowledge, be it concerned with large or with little things. The orbit of a subatomic ion is as important as the path of a distant star with a parallax of a fraction of a second of arc, though the former we may hold in the hollow of the hand, and the light from the latter, starting before we were born, may not reach us till we have gone on our own long journey. A man may work a lifetime to secure such a fact as that, but he lays his tribute upon the entire universe in doing it, and he inscribes the mark of immortality upon his name. Nature deals with facts, honest work, and inspiration. She rewards man with the happiness which comes to his mind through the consciousness of effort, possibly with success, and the chance to multiply his single talent a thousandfold in the service of mankind. However, in a practical way, science seems to develop in three threads of effort—statistical, economical, and theoretical—and in a completed science they are mutually interwoven to support one another. Astronomy has its star catalogues, its Nautical Almanac, and its Theoria Motus; these are its facts, its theory, and its forecast. Electricity and magnetism has its physical measures in the laboratories made by nature and by man, its magnificent mathematical analysis, and its telegraphy from city to city, from land to land, and between the sun and the earth; also its dynamos and its physical chemistry.

Meteorology has its climatological statistics, its synchronous charts and forecasts; and alas, would that we could also add its theory in satisfactory form. Furthermore, these three-stranded ropes of astronomy, of electricity and magnetism, and meteorology, are in nature but parts of the great cable that binds together the sun and the earth, which may be called the solar-terrestrial physics. We are but just entering upon an adequate conception of this truth in recent years, and are slowly and even painfully unraveling the threads of this grandest of all problems, so enormous in extent as to task severely the powers of the strongest minds to master even the general relations of its parts, and so difficult in its details as to baffle our keenest analysis and imagination. It is my purpose to-day to speak of this great subject as I see it, hoping to convey at least some proper idea to you of the splendid field of thought that it has been my privilege to work in, since my first attachment to the Cordoba Observatory under the Southern Cross. Is it not, by the way, a singular fact that the three Americans who have so far made a serious effort to solve the dynamical problems of meteorology, Professors Ferrell, Abbe, and Bigelow, each began their studies as astronomers and passed over into meteorology in their riper years. We have respectively served in observatories, in the Nautical Almanac Office, and in the Government service for meteorology. We became acquainted practically with numerous

observations, long and tedious computations, and developed a sort of imagination capable of conceiving problems on a grand scale, and a patience of study and research before which difficulties tend to yield. This experience may be significant or not; but it is my impression that the meteorologists of the future will be recruited from among the astronomers rather than from the physicists of the laboratory. In a word, the highest problems of meteorology are in effect astronomical, since they are concerned with the equations of motion. Meteorology is, however, even more difficult than astronomy, because it must employ the hydrodynamic equations instead of the dynamic, and they are necessarily much more complex. But astronomy is fast becoming astrophysics, and there the two branches of this great science flow together and become mutually related. The question has no doubt presented itself to your minds, Why is it, if the observations, the theory, and the forecasts are so intimately connected in meteorology, that the theory has had so little influence upon the practical forecasts of the Weather Bureau? The answer is probably twofold: First, that the theory has been very imperfect and incorrect; and second, that the officials have not generally qualified themselves as students to use scientific results involving mathematical and physical analysis. As to the first: Scientific progress depends upon three distinct steps, (1) the collection of observations; (2) the development of pure theory as a mathematical analysis, and (3) the comparison of the possible solutions in mathematics with the results of observations.

You may have noted that this procedure has been followed in the three investigations which I have carried out since my connection with the Bureau, viz, the relations between solar and terrestrial magnetism and meteorology, the international cloud observations, and the barometry of the United States, Canada, and the West Indies. In each case the whole mass of observations was compiled ready for analytic treatment. At the same time all the mathematical discussions heretofore available have been studied, classified, and clarified ready for application to the reduced data. The third step of welding the observations and the theory together is only partially completed up to this time. The immediate consequence of this method is to severely test and criticise the existing speculative meteorology current in our books and in the popular understanding. It is necessary to say that I have been surprised and disappointed at the weakness and inability of many well-known views to bear this strain. To illustrate very briefly: In barometry we have had five methods of reduction to sea level, by Guyot's Tables, the Monthly Constants, the Ferrel Tables, the Hazen Tables, the Morrill Tables. My conclusion is that Ferrel's point of view and method of reduction is admirable, and that the Hazen system ought not to have superseded it. Hazen's method takes no true account of the plateau effect, of the vertical temperature gradients, of the difference between the current and the normal pressure. His argument from Mount Washington as an analogue to the Rocky Mountain Plateau is not sound. But I must say that his device of reducing the station pressure as if the sea-level pressure were 30 inches works in the same direction as Ferrel's correction, so that his practical results for forecasting are approximately correct, except in the cases of cold waves on the northern plateau and the hot waves on the southern plateau. I understand that the real reason why Ferrel's method was abandoned is that the Signal Service could not sufficiently understand it. Yet in effect it is a method simple in principle and easy of application, as you will no doubt admit when the subject

is brought to you in a different form. We have recently improved the Ferrel method and extended it to the sea level, the 3,500-foot plane, and the 10,000-foot plane, so that daily maps can be constructed upon one as quickly as upon the other of them. The forthcoming report on barometry contains normals of pressure, temperature, and vapor tension at the station and on these three planes. It is my belief that theory and practice in barometry will support each other satisfactorily in the future.

Regarding the theory of local cyclones and the general cyclone of the hemisphere, it can only be stated here, in my brief paper, that the Ferrel local cyclone does not exist in nature, because there are no boundaries about it, as is assumed in the analogue of a cylindrical vessel holding a mass of circulating water. The German local cyclone is likewise an ideal one, because there is no powerful central vertical current such as that theory requires. The Ferrel canal theory of the general circulation is only true in part, because the interchanging motion is not wholly from the Tropics northward in the upper strata to the poles and thence southward in the lower strata. The great currents, on the other hand, move northward and southward on the same levels most rapidly in the stratocumulus level, and in trying to pass by each other they generate our cyclones and anti-cyclones, which are practically confined to the strata within 2 miles of the ground. Criticism has done its work, and rejected an entire literature of meteorology. The constructive process must now be continued. The problem is quite clear to my mind, but the analytic difficulties are very great, and I may not succeed in resolving them myself. I shall be quite content to have placed the right point of view before some abler student of hydrodynamic forces and motions. The original trouble came from speculating in the mathematics without a knowledge of the facts themselves to be accounted for. If the results of the International Cloud Observation of 1896–97 had been in hand, much that we now call meteorology would not have been written. The official reports of the seventies show that Professor Abbe was urging nephoscope and altitude observations in those days. It is a pity that his advice was not followed. Consider the time and labor wasted and money uselessly expended in trying to construct a theory of meterology from guessing as to the motions of the upper atmosphere. A few thousand dollars spent then would have been the best of investments. It is now a thankless task to try to reverse a theory of science that has gone forth; it is better to build upon than to destroy the work of our predecessors.

The problem of solar and terrestrial magnetism still remains in the crucible of scientific criticism, owing to the difficulty of handling the observations and accounting for the results. My own investigation constitutes the most comprehensive and thoroughgoing of any yet undertaken. The method of treating the observations by deflecting vectors is universally accepted and will take its place permanently in science. So far as others have carried their computations, our results are in harmony, but no one has yet covered the field fully enough to be better competent to draw more correct conclusions. Pupin's and Ebert's experiments, together with the theory of ionization, interpret the corona as an electric radiation controlled by a magnetic field; Van Bemmelen finds a distribution of the polar field at the earth like mine; Schuster's distribution of disturbing vertical vectors is the same as mine; the theory of ionization seems to account remarkably for several gaps in the theory which I adopted to account for my results. I am convinced that I shall have less to modify than

others who wrote upon the subject several years ago. Ionization has already sent a thrill of delight throughout the scientific world. An attempt has been made to review and correlate the present aspect of the entire problem in my report on the total eclipse of May 28, 1900, and I am glad to see that the Weather Review is beginning to take cognizance of this splendid subject by quoting Wilson's paper in a recent number.

It is not too much to say that meteorology is turning over a new leaf in these days. Speculative theories are being discarded, and we must build anew upon the motions of the air as disclosed by cloud observations, and upon the gradients of pressure, temperature, and vapor tension as measured in kite and balloon ascensions or by cloud computations. The new machinery of mathematics and the computing tables have been reconstructed as satisfactorily, normals have been worked out on three reference planes, and ionization has been admitted to explain the atmospheric electricity and magnetism, also the residual effects of radiation. Work opens up to us for the immediate future more exacting and more promising than anything we have known in the past, and it calls for better scholarship, more men, and more money. Our experience shows how unwise it has been to hope to solve the practical problems of forecasting without any more data than we could pick up from the ground. You know as well as I do how much progress has been made toward any important improvement in the forecast during the past twenty years. At the same time the commercial demand for better forecast work is pressing us very hard, and our mistakes are more deeply regretted than they were years ago.

There is a curious alignment of meteorologists going on in the world, brought about by natural causes. While the opportunity and the demand for practical meteorology has put America at the front in this respect, we must admit that the Europeans are doing better in theoretical and in exploring work. They have many more scholars in mathematics and physics than we have, and while kite work has been pursued about alike in both countries, the balloon observations, upon which results in the higher strata depend, are being made entirely on the other side of the water. It seems to me that we ought to even things up a little at this place. The labor of research is much too great for the few of us now assigned to it in the central office. I believe I am correct in saying that the Chief of the Weather Bureau and the corps of scientists are unanimously in favor of expanding our research work by adding to our present organization a new division for that purpose. Such investigation must go on continuously, not tentatively in small pieces as emergency arises. The path before us is perfectly clear, and it is only a question of labor to solve our problem. I do not, for one, think we are longer justified in continuing to conjecture regarding the elementary facts concerned with the dynamics of storms.

THE ADVISABILITY OF SUPPLYING EMPLOYEES WITH APPARATUS FOR CARRYING ON ORIGINAL SCIENTIFIC INVESTIGATION UNDER CERTAIN CONDITIONS.

By Mr. Weston M. Fulton, *Knoxville, Tenn.*

In his work entitled The Aims and Methods of Meteorological Work, Prof. Cleveland Abbe says:

> The proper aim of a weather bureau must be to do its part in the development of all four aspects of scientific activity—observation, induction, deduction, and

application. Efforts have sometimes been made to show that a popular government is, and should be, a purely utilitarian and popular institution and that its duty is to develop the art of applying the sciences, not that of constructing them. But every art is imperfect in its beginnings. If a weather bureau is to apply meteorological science for the benefit of the community it must be careful to see to it that this art of prediction progresses equally with the general progress of science, just as is the case in astronomy, chemistry, and the exact sciences. Moreover, it must stimulate the growth of the highest phases of meteorological science. It must stimulate investigation in order that it may have a solid foundation whereon to build improvements in forecasting.

There must therefore be a certain proper proportion in the work of every weather-bureau station between the attention given, on the one hand, to observations and predictions and, on the other hand, to investigation. It is only by the increase of knowledge in both these fields that the practical utility of a weather bureau can continue to respond to the increasing demands of the people who support it.

The experimental side of meteorology is usually less prominent than its observational side; nevertheless, there are many questions involved in this science that must be settled by experiment and measurement in physical laboratories, as distinguished from the observations made at meteorological stations.

It is believed that all must concur with Professor Abbe in the foregoing conception of the true aim of a weather bureau. It is not my present purpose, therefore, to enter into an unnecessary argumentative discussion of the scope of a weather bureau's work, but my desire is to emphasize one particular feature of this work, the importance of which claims for it the careful consideration of every employee of the United States Weather Bureau. I refer to the work of original scientific investigation.

The history of nearly all important scientific discoveries shows that they require, not only much labor and perseverance on the part of the investigator, but also the expenditure of more or less money for experimental purposes. The necessary funds have, in some instances, been supplied by the investigators themselves, while in others they have been supplied by moneyed men who were interested in science, or by public institutions. It is therefore plain that there are two conditions which must be fulfilled in order that progress may be made along this line. These conditions are: First, there must be independent thinkers and investigators; secondly, there must be appliances with which the investigator may conduct his experiments.

If there is a dearth of scientific investigation on the part of employees in the Weather Bureau, I do not believe it is because the first condition named is not fulfilled. It is my belief that not only at the central office, but also on station are to be found employees who have original ideas, and whose ideas, if developed, would in many cases redound to the advancement of meteorology and to the public usefulness of the Weather Bureau. Yet these ideas continue, year after year, in the embryonic state. Is this not due to the fact that the second condition which we have laid down is not fulfilled in our Bureau? It would be difficult, if not impossible, to find throughout the enlightened world to-day a class of men who receive less pecuniary compensation for their labor, when the character of this labor is considered, than do employees in the Weather Bureau. And I maintain that so long as the average salary in the Weather Bureau remains about one-half that received by the average university professor, original scientific investigation by Weather Bureau employees to an extent and of a character commensurate with public demands will always remain without Government aid an impossibility. The writer has himself, during the past few years, spent a small portion of his salary in purchasing apparatus for experimental purposes, and no one

will be surprised to learn that he was finally forced to abandon his experiments because the equipment was entirely inadequate.

It seems to me that the time is now at hand when we, as representatives of an important scientific bureau, should take concerted action to secure the funds necessary to fully develop this important feature of our work. Nor do I believe that this will by any means prove a difficult task. In fact, I wish to say plainly that, while I do not maintain that we have been altogether neglectful in this direction, whatever of dereliction may have existed is chargeable to no one except ourselves. The Chief of Bureau and his scientific corps have undoubtedly encouraged original thought and endeavor in every way practicable. It would be presumptuous to suppose that our legislators in Congress would fail to perceive the ultimate economic value of such an appropriation. It is incredible that a Government which expends annually about $1,000,000 for the maintenance of agricultural experiment stations, should hesitate to foster analogous experimental work in the Weather Bureau.

Of course such funds should be equitably distributed and judiciously used. It is beyond my province here to discuss at length ways and means whereby this might be accomplished. The experience gained by our Government in handling agricultural experiment-station funds during past years should make it possible to devise a system which would prove in every way satisfactory. However, in order to more fully define my attitude in the matter, I should say that some important features which should be incorporated in such a system are:

I. The central office should have full control of the funds and general supervision of all investigation.

II. The funds should be distributed annually only to such employees as indicate a desire to conduct investigations under the following conditions: (*a*) The investigator should be able to show that he is not proposing to duplicate previous work, i. e., that his ideas are original; (*b*) his work should be designed toward the advancement of meteorology; (*c*) his investigations should be conducted outside of regular office hours, and not in lieu of any other official duties; (*d*) he should render a strict account of all funds expended. The sole incentive to his action should be the thirst for knowledge and the desire to promote the public usefulness of the Weather Bureau by scientific discovery.

A practical system embodying these features may be briefly outlined. A committee, or board of supervisors, should be appointed at the central office, consisting, perhaps, of the editor of the Review and the chiefs of divisions, with the Chief of Bureau as chairman, to pass upon all applications and to make an equitable distribution of the experiment fund. At the beginning of the fiscal year, when the fund becomes available, a circular should be issued to all employees of the Weather Bureau, naming the amount of the fund and stating that the committee is prepared to consider applications from any who desire to conduct experiments under the conditions named above. A reasonable length of time, say thirty days, should be allowed employees to prepare their applications, after which time no applications should receive consideration until the beginning of another fiscal year. This would make it possible to inform each investigator definitely as to the funds which could be allowed him for the fiscal year, and thus enable him to shape his work accordingly.

Upon the receipt of the circular from the committee, each employee

desiring to pursue any line of investigation should carefully prepare a lucid outline of his proposed investigation, clearly indicating the lines along which he proposed to experiment, the results sought, the equipment already on hand, if any, and the additional equipment which would be necessary during the fiscal year; these papers to be forwarded to the committee for consideration. In passing upon applications the sole criterion should be originality. Too great care could not be exercised by the committee in avoiding prejudices arising from personal opinions as to the feasibility of the investigator's ideas. It would be necessary to constantly bear in mind the fact that discovery necessarily implies an advance beyond present knowledge, and often the upsetting of generally accepted conceptions. The broadest liberality should be exercised, and every employee who has an original idea should be given an opportunity to develop it regardless of its apparent merit or otherwise. All applications having been passed upon, the rejected applicants, if any, should be fully informed regarding the grounds upon which their applications were rejected, and references should be cited, when practicable, to show that the same line of work had, in all respects, been previously carried out by others. The funds available could then be equitably distributed among successful applicants. At the end of each fiscal year, each investigator should render a strict account of all funds expended, and make full report of the progress of his work. Results obtained, whether positive or negative, should be summarized. These would naturally be published in the annual report of the Chief of Bureau. An important discovery might, however, be at once announced in the Monthly Weather Review. An investigator who failed to obtain satisfactory results after a reasonable length of time should be required to discontinue, at Government expense, the particular line of investigation in which he was engaged.

While the plan indicated by the foregoing outline might be improved upon in actual practice, no thoughtful person will look for a system altogether free from objections. An objection which is sometimes unthinkingly opposed to schemes of this character is that many investigators would spend greater or less sums of money without achieving any valuable results. This objection is as astonishing for its lack of forethought as it is for its complete absence of foresight. It is eminently worthy of the mind which is "penny wise and pound foolish." Every well-informed person knows that the few scientific discoveries made by the great army of investigators in the past have afforded a manifold return for all the money and labor expended. Should any such system as that which is here proposed be inaugurated in the Weather Bureau, it should be expected that discoveries will be "few and far between:" but does anyone doubt that a few new ideas added to our present relatively sparse knowledge of meteorological laws will more than compensate for the failure of the majority of investigators?

The work of the Weather Bureau is distributed over a vast territory, extending from the north frigid zone to the tropics. Within this territory are to be found a great variety of meteorological and climatic conditions. A richer field for original thought and investigation could scarcely be found. Some employees are located in close proximity to scientific institutions to whose laboratories and libraries they have access. The study of the physical and mechanical principles which underlie meteorological changes might, in such instances, be studied to advantage.

As one deeply interested in the progress of the work of the Weather

Bureau, I will herald with gratification the day when each and every employee has some meteorological problem, however simple it may appear, in which he is so much interested that he can not refrain from devoting to its solution a liberal share of his spare time and thought; for I believe that this will mark the beginning of a period of scientific, as well as practical, advance in the service, which will be gratifying to its employees and highly acceptable to the public.

DISCUSSION.

Prof. ALEX. G. MCADIE: The trend of modern activity is toward specialization. It is an age of experts, and an expert may be defined as one who can give the right information at the right time to the right inquirer. Assuming that there is need for experts in our chosen field, and that the men are available, how shall we get them? First, offer a favorable environment; second, the privilege of experimenting along given lines.

To illustrate the impetus which favorable environment gives to research and investigation, let me cite the Pacific coast, where we have a profusion of flowers and fruits. Most lavishly does nature offer, under a genial climate, the fairest products of tree and vine. It is because of these favorable conditions that man attempts to develop further types of fruits, flowers, and vegetables. In other lands the man who makes two blades of grass grow where previously but one existed does well, but here these horticultural wizards give the poppy, the violet, and the rose robes more beautiful than dear old mother nature with all her means and generous impulses ever previously gave her wild daughters. To such men the fruits as we know them are but prototypes of a multitude to come of rarer excellence and higher character. As children we long to be Napoleons, winning battles in which men are mowed like the grass of the field, but as men we would fain be Burbanks, taking the most neglected and contemned weed, downtrodden and despised of all, a veritable Ishmael of the field, and, recognizing its one redeeming trait, lift it to a stage of usefulness. We might well envy these wizards of horticulture who win such victories were it not that our own field of work is equally fascinating. A raindrop seems a commonplace affair, but, if we knew all, the universe is not more marvelously held together. And where is there a more entrancing life history than that of the water vapor as it rises, the breath of ocean, from the level of the seas to the realm of the clouds, journeying hither and thither, imprisoned in banks of fog, or sailing high in summer skies, enjoying long its freedom, and when at last it falls, unlike all other fallen spirits, it blesses, bringing with it as playfellows to earth the rarest lights of heaven!

What do we know of the physical processes of cloudy condensation in the free air? Try to make a cross section of a fog bank and chart the temperature distribution, using only mercurial thermometers. You will realize that instruments much more sensitive to heat radiations are necessary. Our hygrometers likewise give but a very general integrated indication of the work that is done—of the energy that is utilized. The heat of vaporization and the heat of fusion are not clearly indicated by our present instruments. In fact, we are in the predicament of a maker of fine watches who is restricted to the use of a crowbar and sledge hammer; very serviceable tools for some purposes, but not for repairing delicate hairsprings or fine balance wheels. Has it ever occurred to you that we who live in the twentieth century

and read in the morning's news the temperatures and rainfalls over a continent would be considered "all knowing" by the people of the seventeenth century; for the thermometer was unknown before Galileo's time, and the barometer was not invented until 1643? And what will the people of the twenty-first century know of atmospheric processes? Will apparatus keeping faithful account of the energy from all incident radiations be in general use? Will radiations of all wave lengths be accounted for each day? Will the thermopile, the radio-micrometer, and the bolometer seem as crude and clumsy to these coming ages as the philosophical apparatus of the nineteenth century now seems to us?

We know relatively less about radio-active substances than the philosophers of Franklin's time knew about heat. It is but a few years ago since Becquerel called attention to the action of the uranium compounds under sunlight. Elster and Geitel, together with Zeleny and T. C. R. Wilson, have shown us that electrified bodies lose their charges under the influence of certain radiations, and that an ionizing of the surrounding air may thus be effected. It is said that the ultra violet rays of sunlight ionize the upper air strata, and that water vapor condenses more readily on negative than on positive ions. What great practical applications of cathode and Röntgen rays are yet to be made in the field of meteorology? Who will utilize the radio-activity of the thorium compounds, or those unearthly substances, radium, polonium, and actinium, which have but recently been isolated by Professor and Madame Curie?

I am not competent to speak of the recent advances in theories of electro-chemical change. The work of Prof. J. J. Thomson on electrons, those minute associates of the atom, is, however, too significant in connection with the ionization of air at atmospheric pressure to be passed over without reference before a body so deeply concerned as this convention is with all questions relating to the formation of the raindrop.

Problems connected with gaseous dissociation and the passage of electrical discharges through air, under different conditions of pressure and temperature, are now in the laboratory stage, and we are beginning dimly to see what a wonderful chain of physical processes is involved in an electrical discharge through air. Let us hope that it will not be long before the meteorologist applies practically these new discoveries. In a line of work more familiar to the speaker, viz, that of atmospheric electricity, there is room for much investigation. There are problems connected with the lightning flash, and, indeed, with every form of electrical discharge in air, which can be partially solved because of the experiments of Hertz, Lodge, and others upon resonance in Leyden jar circuits.

A few weeks ago a member of this convention read of a patent granted abroad for the use of a coherer in recording distant thunderstorms, and that an instrument based on this principle was in successful operation. It was gratifying to him to know that such an instrument existed, for in one of his notebooks some years ago just such an instrument (so far as can be ascertained) was sketched out.

Wonderful indeed has been the progress in etheric telegraphy, but think what further applications await the meteorologist.

By sheer force of modern methods and apparatus some six years ago Rayleigh and Ramsay dragged argon from the nitrogen of the atmosphere, and since then, by reason of the discovery of argon, how many new gases have been brought to light—e. g., helium, krypton,

xenon, and neon. In 1823 Faraday liquefied chlorin. Oxygen was not liquefied until 1877, and nearly every chemist twenty years ago would have said that the chances were that hydrogen never would be liquefied, but in 1901 Dewar and others solidify hydrogen and obtain temperatures as low as 15° A. to 13° A. (−258° C. to −260° C.). It may well be said that the nadir of temperature is within hailing distance.

When, then, a man who has the hall-mark of investigator stamped upon him asks for such apparatus as in his judgment is needed to carry out a legitimate line of investigation, he should by all means be encouraged, for it is a sure truth that through the labors of such men mankind moves forward, mastering slowly the forces of nature and utilizing for the good of all, energy otherwise wasted.

STUDY OF SKY POLARIZATION WITH REFERENCE TO WEATHER CONDITIONS.

By Mr. L. G. Schultz, *Fort Worth, Tex.*

It would be interesting, by way of introduction to the subject in hand, to begin with a statement of the many theories that have been advanced regarding sky polarization; but in the limited time at our disposal this will be impossible, and so it must be assumed that we all are familiar with the most important ones of these theories as well as with the investigations that lead up to them. An excellent résumé of many of the most important papers that have been written concerning the polarization and color of the sky, together with a comprehensive bibliography of this and relevant subjects by Dr. N. E. Dorsey, of the Johns Hopkins University, was published in the Monthly Weather Review for September, 1900; and the extent of our present knowledge regarding sky polarization is fully shown in this article.

We all know that if a beam of ordinary light be made to pass across a dark room its path is visible at all angles of observation because its light is scattered by being reflected and re-reflected an infinite number of times by the myriads of small particles of matter that lie within it, and that the illumination of the beam increases up to a certain limit as the number of such particles increases. To the unassisted eye such a beam of light presents no special characteristics; but if it be examined with proper instruments in a manner suggested by Professor Tyndall, in the course of his very interesting experiments with light, it will be found that many of the light waves emanating from it are greatly affected by the minute particles of matter with which they come in contact. By using special devices for intensifying the effects that may be observed in nature, Professor Tyndall showed that, while the largest particles scatter light of all wave lengths—that is, scatter white light—the smaller particles scatter fewer waves from the red end of the spectrum, and the smallest ones only scatter waves from the blue end, where the waves are shortest; and he also showed that the light scattered laterally from the finest particles is polarized—that is, the vibrations within the medium through which the light is propagated, instead of taking place in an infinite number of planes, making all possible angles with the plane along which the light travels, as is the case in white light, after impact with the finer particles of matter are constrained to take place in a single fixed plane which makes a constant angle with the original plane of incidence.

When light waves are so constrained to move in a single plane, the

plane in which the motion takes places, as well as the angle that it makes with the original plane of incidence, may be measured with a polarimeter; and it is with measurements of this kind that we are chiefly interested in studying the polarization of the sky. The light effects produced in the laboratory on a miniature scale by Professor Tyndall are every day produced on a grand scale in the atmosphere. According to Tyndall's law the large particles, composing the dust, clouds, and haze, reflecting indiscriminately waves of all lengths, appear white, while the smallest particles suspended in the atmosphere, reflecting only the shortest waves, cause the clear sky to appear blue. The effects of polarization may, under favorable conditions, be observed with the naked eye, but they can be seen at any time, between sunrise and sunset, by looking at any portion of the sky through a polariscope. The most marked effects will appear in the vertical plane passing through the sun. The maximum polarization occurs at points about 90° away from the sun, so that at sunrise and sunset the light from the zenith is mostly polarized, and at high noon this effect will be observed near the horizon.

When a beam of polarized light passes through a space occupied by a great number of large particles, it becomes partially depolarized by being successively scattered in all imaginable planes; and so it is that the sunlight, which is probably completely polarized in the clear regions of the atmosphere aloft, never reaches us in that condition, on account of the presence in the lower strata of the air of large numbers of coarse particles of matter. But these coarse particles are separated by distances that are very great relatively to the lengths of light waves, so that the light is at least partially polarized even when the sky is completely covered with clouds. It may be stated, roughly, that the amount of polarization in light from the sky is inversely proportional to the number of coarse particles floating in the atmosphere, so that it reaches a maximum on bright, clear days and decreases upon the appearance of dust, clouds, and haze.

These variations, due to agencies within the atmosphere, have suggested the utility of polarimetric observations in studying weather changes; but up to the present day this field of work has received very little attention. During 1873 Prof. E. C. Pickering, now director of the Harvard Astronomical Observatory, in a paper read before the American Academy of Arts and Sciences, showed that the sky was uniformly polarized at all points equally distant from the sun. His observations showed some variations, and these he ascribed partly to errors of observation and partly to real irregularities in the atmosphere, which, he concluded, followed no regular law. It should be noted here that Professor Pickering's investigations at the time were not directed to the study of the meteorological questions involved. During the past three years his experiments were repeated at several of the Weather Bureau stations with a view to studying these variations. The instrument used was practically the same as the one used by him. It consisted of a double-image prism fixed at the end of a flat iron bar. One end of the prism was covered with a cap in which there was a small circular hole just large enough to bring its two images in contact. At the other end of the bar was a heavy iron frame placed vertically with reference to the axis of the bar. To this frame there was fixed a circle graduated to degrees. A brass tube, in which a Nicol prism was mounted, was placed so as to occupy the space at the center of the circle. To the outside of the tube was attached an arm which extended to the graduations on the circle. The end of the arm was

graduated to show fractions of a degree, so that when the Nicol was rotated the angle through which it moved could be read to the hundredth part of a degree. The prisms were so adjusted that the images caused by the double-image prism could be observed through the Nicol. When the light impinging upon the former was unpolarized, the two images were equally bright, but when it was polarized one was brighter than the other. In the latter case they could be made equally bright by turning the Nicol; and if the instrument was properly adjusted the angle through which the prism was turned gave the necessary data for determining the amount of polarization of the light.

For making observations the bar carrying the prisms was attached to the side of a heavy wooden frame, with square edges, by means of a bolt and nut. It was free to rotate around the bolt as an axis, and a graduated circle drawn on the side of the frame showed the angles through which it turned. The side of the frame to which the bar was attached was kept normal to the sun's rays by means of leveling screws. With the instrument thus mounted observations were made on points 90° from the sun at sunrise and sunset. It was found that the early morning and late evening were the best times for observing, as the sky was then freest from clouds, and the effect of earth reflections was a minimum in a plane passing through the zenith. Noon observations on points near the horizon gave very unsatisfactory results on account of the great amount of cloudiness at that hour and large variations due to topographic features.

Twenty-three series of observations were made at Walla Walla during the months of January and February, 1899; 35 at Spokane during December, 1898, and March, 1899; 95 at Kalispell during the year 1899, from April until November, and 88 at Fort Worth during the years 1900 and 1901. These observations gave rise to a series of polarization curves that do not agree among themselves. Each station is represented by a characteristic curve. Theoretically these curves should be straight lines, but owing to earth reflection at the lower altitudes the lines dip at the ends. The dip is most marked in the curves for the northwestern stations, where the horizon is broken by lofty mountains. By drawing separate normal curves for the morning and the evening it was found that the polarization in the morning was greater than in the evening. The difference was least at Kalispell and greatest at Fort Worth; but at the latter station the evening observations outnumbered the morning six to one, as station duties interfere with morning observations there. By comparing each series with its appropriate normal curve it was found that variations in polarization were much more irregular at sunset than at sunrise, and that great variations at sunrise were more often followed by atmospheric disturbances than great variations at sunset. Polarization above the normal and increasing was found to indicate settled weather. Abnormally low polarization was usually followed by cloudy weather, and the clouds generally appeared in the portion of the sky where the polarization was weakest.

While making these observations it was found that the polarimeter may be used to good advantage in cloud observations. Even on cloudy days, with the sky entirely overcast, it would indicate whether the clouds were dissolving or growing denser by showing an increase or decrease in the amount of polarization. Patches of cirrus and cirrostratus clouds were often watched for hours at a time, and frequently the polarimeter indicated that rapid changes were taking place, while to the naked eye the clouds appeared to maintain a constant size and

shape. In showery weather, when the air is heavily laden with vapor, even though the amount of cloudiness be small, the polarization is weak. With fair-weather conditions, even with the sky thickly dotted with heavy cumulus clouds, the light from patches of clear sky is highly polarized.

DISCUSSION.

Professor ABBE. I think the few of us who have tried polarization work ought to compliment Mr. Schultz on doing a very nice piece of work. He actually invented and made his own instrument, and now has worked with it apparently for three years and has got some very good comparisons between his results and the weather, which is a new feature. There are several published German memoirs, with notes of observations, and the general conclusion is that there is no immediate, no clear, relation between the weather and the polarization. But Mr. Schultz is striking out in a new path, and I think we ought to wish him good luck.

Professor MOORE. I heartily concur in what Professor Abbe has said. Mr. Schultz has outlined, independently, a course of investigation that many others taking up a similar subject for investigation might pursue. It is directly in line with the ideas of Professor McAdie and Mr. Fulton. We are developing some young, bright, vigorous scientists, and I think probably this convention will accomplish something in the way of inaugurating a system whereby they may have support, financial or otherwise. [Applause.]

FOG STUDIES.

By Prof. ALEX. G. MCADIE, *San Francisco.*

"When this mortal shall put on immortality!" Thus did a great logician twenty centuries ago express the yearning which comes at times to all earnest natures for a change from the dull things of life to the illimitable, ever-certain freedom of the skies. To a man upon a mountain the baseborn fogs of the valley are ever suggesting change. For he sees these wanderers climbing upward with almost painful progress, now falling, now rising on the mountain's flank, until fairly on the peak for a few brief moments they rest, and then, springing free, they spurn the lower hills, and, as full-fledged clouds, pass forever away. Their shadows only, like the memories of departed worth, remain upon earth.

"Fog," says the traveler, "is an unmitigated nuisance." "Fog," says the mariner, "is the shadow of doom." "Fog," says the aerophysicist, "is the first step in rain making, Nature's significant hint to man to follow more closely the process of cloud building, and to peer into the seeming mysteries connected with that Protean element, the water vapor of the atmosphere."

The alchemist sought to transmute the so-called baser metals into precious ones. The chemist to-day, more sure of his ground, changes the form even of the most refractory gas into a liquid or solid. Thus hydrogen at a temperature of $-255°$ C. is a white solid substance. This change of form we are told has been accomplished by three different processes, which may be called, respectively, vaporization cooling, work-expansion cooling, and free-expansion cooling. To change the vapor of water to water or to ice requires a much less range of tempera-

ture, and we frequently find under natural conditions these transformations occurring.

There are places on the coast of California where the soft sea breeze stirs only the leaves of the lemon and orange trees. There are other places on the same coast where the wind from the ocean bears to the land a bank of snow-white water vapor. With almost clock-like regularity in the vicinity of the Golden Gate on summer afternoons the velocity of the wind rises to about 22 miles per hour and through the Gate comes a solid wall of fog, averaging 1,500 feet in height and causing a fall in the temperature to about that of the sea, namely, 55°. The topography is such that sharply defined currents form in the lowermost strata of the air. From the summit of Mount Tamalpais one looks down westward upon the broad expanse of the Pacific; to the south, beyond the Sausalito hills, a narrow passage of water connecting the Bay of San Francisco with the ocean, and to the east the entrance to a great valley, 450 miles long and 50 miles wide. It is no unusual thing on a summer afternoon to have within a distance of 50 miles in a horizontal direction a difference of 50° in temperature, while in a vertical direction there is often a difference of 30° between sea level and an elevation of 2,500 feet. The conditions prevailing in winter, when tule fog forms in the great valleys and drifts slowly seaward, are very different from those prevailing in the summer, when the sea fog is carried inland; but even in winter it is to be noticed that the temperatures upon the foothills and mountain peaks are from 4 to 6° higher than in the valleys. An illustration of this may be found on the mornings of December 5 and 6, 1900. The temperature at sea level did not exceed 45°, while at an elevation of 2,000 feet or more the temperature at the same moment was about 60°. As a type of summer fog, August 10, 1901, may be instanced. (See plates I and II.)

The object of this paper is to emphasize the point that fog may be considered as a problem in *air drainage*, just as frost may be so considered. The invisible vapor becomes visible either as cloud, fog, or frost, and our problem is to study and control, if possible, the expansion and compression of the aqueous vapor near saturation temperature. Omitting the changes in pressure—for with diminished pressure comes vapor expansion and cooling—we are to concern ourselves chiefly with such temperature changes as occur near the earth's surface. The cooling may be effected by an ascensional movement, or by contact, with the relatively cool water surface in the case of summer fog and with the land which has been cooled by rapid radiation at night in the case of the tule fog, or by mixture.

It is probable that the last named is the more active agency in the production of the fogs near San Francisco, inasmuch as we have a stream of air and vapor at a temperature of about 55° F. injected into a mass of air and vapor rather quiescent, as a rule, at a temperature of 90° F. It is believed that the fogs shown in the accompanying illustrations result from the sharp temperature contrast at the boundaries of certain air currents and that the contours of the land play an important part in originating and directing these drafts.

Recently there have been several excellent articles in the Monthly Weather Review on "Rainfall from convectional currents and the theory of the formation of precipitation on mountain slopes." The equations given in these articles can in the main be applied effectively in the discussion of these fogs of the Golden Gate, remembering that instead of a vertical flux we have to deal with a horizontal flux. It is difficult to study "in situ" the cooling of ascending air; but under

Plate I. Pacific Coast Weather Map, August 10, 1901, 8 P. M. (75 meridian time), showing summer fog formation.

Plate II. Pacific Coast Weather Map, December 5, 1900, 8 A. M. (75 meridian time), showing winter fog formation.

such favorable conditions as exist near Tamalpais the effects of any stoppage or slow motion of the horizontal currents might be investigated even as they occur. It is plain that such discussions are bringing us nearer to an understanding of the processes at work in the making of the raindrop.

Thus far we have considered only questions of formation, but almost of equal importance to man are the questions dealing with the dissipation of fog. If you will study statistics relating to marine disasters and also railway disasters, you will be impressed by the frequency with which the word fog appears as either the direct or contributory cause of the accident. Even if we were able to dissipate fog only within a distance of a few hundred feet around a fog-bound vessel, many an accident would be prevented. It is true that at present the problem appears like attempting to cut away a snow drift with a small shovel. But rotary snow plows to-day accomplish what years ago seemed well nigh impossible; and I do not believe we are over sanguine in hoping that the time will yet come when on large vessels and at certain crowded railway termini some effort will be made to dispel the fog. Dr. Lodge has suggested various methods, of which may be mentioned filtering, clarifying, recondensing, calcining, and electrifying; and with some of these methods there is little difficulty at present in removing from limited spaces fog, smoke, or dust.

On February 22, 1901, a Pacific Mail steamship, the *Rio de Janeiro*, almost within speaking distance of the land, struck a reef in what is thought to be a well-protected harbor. Within twenty minutes the vessel had disappeared from sight with 130 of the 210 persons aboard. The low-lying land fog had caused the vessel to come to anchor about 6 o'clock on the preceding night. At 4 a. m. the fog lifted so that the lights of the Cliff House could be seen; but after the vessel started the fog closed down again and the pilot steered by whistle. Within an hour or two after the accident the fog had dissipated. It does seem that we have here a case in point where the dissipation of the fog for even a few hundred feet around the vessel would have enabled the pilot to locate his position and change the course of the ship sufficiently to insure safety.

The following notes describe the fog pictures accompanying this paper. (See plates III to VIII.)

No. III. *Fog pyramid.*—This photograph was made by the writer July 30, 1900, at 7.15 p. m. The conditions were normal so far as temperature, humidity, and wind go at Mount Tamalpais. The sea-level temperature was approximately 58°; the temperature at a height of 2,500 feet about 62°; the temperature at Point Reyes was about 54°, and this may be taken to represent the temperature of the water. The wind at San Francisco was west, at Mount Tamalpais south, and at Point Reyes light southwest. The view in the foreground is the town of Mill Valley. The apex of the fog pyramid was (it is estimated) about 5 miles from the camera. The fog in the background overlies the Golden Gate and the Bay of San Francisco. The formation is peculiar, and it should be noted that the land under the fog pyramid is level, and the uplifting of the fog is not due to the existence of foothills at this point.

No. IV. *Sunset in sea of fog.*—This photograph was taken in August, 1900, and represents the last view of the sun over a stretch of fog extending westward not less than 30 miles. I waited until I thought the sun had set, but was evidently some seconds ahead of time. The fog filled the valleys to the north and west of the mountain. The general elevation of the upper surface of this fog was about 2,000 feet above sea level; the elevation of the point of view about 2,500 feet.

No. V. *Helmholtzian fog billow.*—This represents a close view of a fog mass forming as described by von Helmholtz. See his Memoir on Atmospheric Movements, read before the Royal Prussian Academy of Sciences at Berlin, 1889. Another

photograph was made showing the condition of this billow after an interval of one minute.

No. VI. *Fog rising and changing into cloud.*—This photograph was taken about 9 o'clock on a morning in September, 1900. In the far distance is seen San Francisco, 14 miles in an air line from the camera. The morning was showery, with fog or cloud resting on the flank of the mountain. The whole mass gradually rose, the showers ceased, and the day was very pleasant. It may be noted that the visibility was very good. The writer recalls distinctly seeing a point on the coast south from the observatory about 30 miles.

No. VII. *Fog billows at Mount Tamalpais.*—This photograph represents the upper surface of fog. As has been pointed out in various papers (see Monthly Weather Review, 1900 and 1901), at a height of from 1,500 to 2,000 feet on summer afternoons a blanket of fog stretches through the Golden Gate and over a large part of San Francisco Bay. It has been found that under such conditions the temperature just about the fog may range from 75° to 90°, while at sea level and in the fog the temperature is about 55°.

No. VIII. *Fog surges.*—This view especially illustrates the air drainage of the district. A strong westerly wind carries the fog up over the Sausalito hills and down again into the canyons and valleys. The current has sufficient impetus to recurve and splash upward when meeting other currents or when deflected by the topography. The houses in the foreground to the left of the rain gauge show the town of Mill Valley.

DISCUSSION.

Professor BIGELOW. I would like to ask Professor McAdie one question. He stated very distinctly that the formation of these fog banks was due to three causes, either singly or interacting, namely: Vertical conveyance, contact of currents, and mixture. The problem of mixture, under scientific treatment, has begun to show that on the whole the amount of precipitation from intermixing is rather slight; and while I have always been inclined to think myself that this process of mixing has a great deal to do with our cloud formation under different circumstances, and thus have found myself in conflict with the theoretical statements especially drawn up by Von Bezold, I want to ask Mr. McAdie how much he knows about the fact that mixing does occur, and its effect in producing these fog banks.

Professor MCADIE. I am sorry to say I know very little. That is the place to make experiments and find out.

The PRESIDENT. We have a number of guests with us, and we shall be pleased to have them take part freely in these discussions. We have as a guest Mr. Clayton, whom you all know for the excellent work he has done at Blue Hill. It is not necessary for me to say anything about his reputation as a meteorologist. The Weather Bureau has always expressed the greatest good will toward the independent work that has been carried on at Blue Hill by Mr. Rotch, with the able assistance of Mr. Clayton. We hope the spirit will move him to say something regarding these problems.

Mr. CLAYTON. I have enjoyed the papers this morning very much. Professor Moore's suggestion of observatories in connection with the weather service has particularly pleased me, and I hope very much he will succeed in getting it through. All the papers this morning have been papers on which I would like to say something, but Mr. McAdie's fog results have been directly in line with our observations from the top of Blue Hill. We frequently see at Boston, as well as is seen on the Pacific coast, the rolling in of such fog banks. I have stood on the top of Blue Hill when as far as one could see the entire country was buried in fog, only the tops of the hills showing above. Furthermore, I have thoroughly convinced myself that the fog that comes off the ocean is entirely due to mixture. Fogs occur in almost every case where there is a very cold current that flows off the water while above the cold current is a warm, damp southerly current,

FOG PYRAMID, U. S. WEATHER BUREAU OBSERVATORY, MOUNT TAMALPAIS, CALIFORNIA.

Plate IV.

Sunset in a Sea of Fog.

HELMHOLTZIAN FOG BILLOW.

Named in honor of Von Helmholtz (see his memoir on such formations).

FOG RISING AND CHANGING INTO CLOUD.

Viewed from U. S. Weather Bureau Observatory.

Plate VII.

Fog Billows at Mount Tamalpais.

PLATE VIII.

FOG SURGES AT MOUNT TAMALPAIS.

usually 10° to 15° warmer, and saturated with moisture. I have watched the process by which it has taken place. I have seen the upper current apparently meet with some resistance, some ascending current set up—as you will see it beautifully illustrated in Professor McAdie's photographs. This column of fog rising into a warm current apparently causes some resistance; it mingles with the warm current and is tipped over and down into the cold air. There mixture takes place immediately and condensation is increased. Intermixture of these two currents goes on until they are churned to the bottom. Condensation, I feel confident, is entirely due to mixture. I have compared the observed conditions of temperature and moisture with Van Bezold's diagram as given in Waldo's Meteorology and have found that mixture of the two currents would produce condensation. I have watched the battle for hours between the fog bank and the warmer current. Almost always the warmer current is driven out. I hope Mr. McAdie can continue his studies along that line, because I think there are a good many interesting problems involved in them.

Professor MOORE. As to the idea of independent observatories, I may remark that we will include laboratories and opportunities for research work. If we come to the time when we can build independent observatories in every city, or the more important cities, I hope we shall be able to add the laboratories necessary for original research, to give our young men the opportunities they are beginning to clamor for.

We have with us, also, to-day Father Odenbach, who, like Mr. Clayton, is a lover of a science devoted to the elucidation of problems that do not attract other people. His voluntary work in making cloud measurements and in kite work at the college near Cleveland was incorporated in our official reports. It was a work of love, and we appreciate it greatly. I should like to have a word from the good father.

Father ODENBACH. I thank you for your kind reception. Like the rest of the body (Society of Jesus) to which I belong, I am always delighted to take up hard nuts to crack, and we try our level best to crack them. I am very much interested in clouds. Perhaps I am saying it in rather broad terms, but in meteorology we are all groping around in the dark, more or less. There is Professor Bigelow, and a great many more in the Bureau, who would like to know something about the motions of highs and lows. One thinks of temperature changes, another of cloud motions. I have a notion that the study of clouds will be found to be one of the keys, if not the key, to the situation. I think that clouds, if we study them carefully for a long number of years, will solve the problem. It is a beautiful study, and always keeps your hands full of work.

Professor BIGELOW. I think the Bureau owes a debt of gratitude to Father Odenbach for his careful and long-continued observations made at the college near Cleveland. This and the work of the Blue Hill observatory are the only instances I know of where an attempt has been made to get at the diurnal motions of the upper strata of the air—in some respects one of our most important problems, because it is difficult to secure hourly observations.

THE PERSONNEL OF THE STATION FORCE.

By Mr. DANIEL J. CARROLL, *Washington, D. C.*

Success or failure in administering the affairs of a great bureau is to be measured not alone by the ability of its head, but as well by the

efficiency of its working corps. As with a military or naval commander, so with a civil chief; he may fail in spite of an efficient force, but he can not succeed with an inefficient one. This aphorism is fully indorsed by the present Chief of the Weather Bureau, and he has said that whatever the degree of success accompanying his administration, it must be duly shared by those whose official actions he was appointed to direct, and whose intelligent, efficient, and cordial support it is his pleasure to acknowledge. Since the great body of weather men are station workers, it follows that in any statement concerning the Bureau the preponderant feature must be an account of its station personnel.[a]

NATIVITY.

Ninety-five per cent of the members of the station force are native-born American citizens. Of the foreign born there are from Austria 2, Canada 4, England (proper) 3, France 1, Germany 5, Ireland 8, Scotland 3, and Spain (Cuba) 1.

PREVIOUS OCCUPATION.

Seventy-three per cent of the members of the station force prior to their connection with the meteorological service were either students, teachers, clerks, printers, or farmers, divided as follows: Students, 21 per cent; teachers, 18; clerks, 17; printers, 10. and farmers, 7.

EDUCATIONAL TRAINING.

Forty-nine per cent have had the benefit of college or university training, 35 per cent completed their schooling in high schools or academies, while only 16 per cent have advanced no higher than the common schools and business colleges. Forty-nine per cent of the first-mentioned class (i. e., 24 per cent of the entire station force considered) are college or university graduates, holding the following literary or scientific degrees: A. B., 25; A. M., 12; B. Agr., 1; B. C. E., 3; B. E., 1; B. L., 3; B. S., 30; C. E., 2; D. D. S., 1; LL. B., 6; M. D., 9; M. E. in E. E., 1; M. S., 5; M. S. Agr., 1; Ph. B., 3; Ph. D., 4.

AGE.

The oldest man in charge of station is 67 years of age, the youngest 23½. The oldest assistant is 64 and the youngest 21½. The average age of the officials in charge is 41 years, and the average age of assistants 35.

MARRIED AND SINGLE.

Seventy-four per cent of the station force are married. Of the men in charge, 78 per cent are married, and of the assistants, 70 per cent, an observer of the opposite sex in charge of a regular station of the Bureau (the widow of a veteran "observer sergeant") being omitted in the count.

LENGTH OF SERVICE.

Seventy-nine men (about 25 per cent of the station force) have been in the service less than five years; 34 men have served continuously

[a] For the purposes of this paper, in referring to the "station force" allusion is made to printers, observers, and higher grades. The figures presented are based on the record of June 30, 1901, or result from the departmental census of March, 1901.

five years; 81 men ten years; 66 men fifteen years; 35 men twenty years; 16 men twenty-five years; 2 men thirty years; and one man has been continuously in the meteorological service since it was organized. For continuous service at present station the record is: Five years, 65 men; ten years, 19 men; fifteen years, 11 men; twenty years, practically. 3 men.

STATION SALARIES.

At the close of the last military administration (June, 1891), the highest salary per annum was $1,246, the lowest $480; the average $963. At the close of the first civil administration (June, 1895), the highest salary was $1,800, the lowest $600; the average $1,111. On June 30, 1901, the highest salary was $2,500, the lowest $840, and the average $1,185.

STATION CHANGES.

The greatest number of changes made by any member of the present station force equals 27, or, including first station, 28. The observer referred to has served twenty-eight years. He has therefore averaged one station a year. He has been at his present station since April, 1895.

Eighty-two per cent of the force hold existing assignments by selection made by the present head of the Bureau; and as showing the wisdom of such selections, the satisfaction or discontent arising therefrom, it may be stated that 85 per cent desire no change of station, and subtracting the number wishing a change for purely personal or domestic reasons—that is, without dissatisfaction as to geographical location—92 per cent will represent the degree of contentment. Of the assistants less than 15 per cent desire a change as assistants.

A few years ago the goal was an assignment to duty at the Central Office. The betterment of the station force in point of salaries and the broadening of its sphere of importance have altered the design of the ambitious. This is demonstrated by the fact that but 15 applications (11 from assistants and 4 from officials in charge) expressing preference for duty at the Washington office are on file.

In connection with this subject the importance of Form 4047—Mis., station preference card, should not be overlooked. This card record of preference is invariably consulted by the Chief of Bureau personally whenever a vacancy in the station force is to be filled. The wishes of applicants for change of station are always considered when changes are to be made, and preferences are granted whenever practicable and compatible with public interests. A case in point is one of recent date. An observer filed a card expressing preference for assignment to a certain station. Shortly after the receipt of the card a vacancy occurred at the station named, and orders for the change were issued. Upon the receipt of instructions to proceed to his new station the employee reported that his preference was to remain where he was. His attention was invited to his card request, which he had neglected to amend, and it being impracticable to alter the plans of the Central Office the orders for the change stood. However, a few months later the observer was returned to the station of his choice.

The average number of changes (including office and station force) ordered per annum by the various chiefs of the service from January, 1873, to June 30, 1901, was:

Myer (during $7\frac{8}{12}$ years), 467; Hazen (6 years), 405; Greely ($4\frac{6}{12}$ years), 245; Harrington (4 years), 122, and Moore (6 years), 122.

APPOINTMENTS, PROMOTIONS, ETC.

During the six years ended June 30, 1901, the average number of appointments per annum was 26; promotions, 60; reductions (for discipline, 6; without prejudice to the employee, 10), total, 16; resignations or transfers to other bureaus (for this Bureau's good, 2; voluntary, 8), total, 10; discharges (for discipline, 5; without prejudice to the employee, 1), total, 6; deaths, 2.

ENTRANCE EXAMINATIONS.

As early as 1870, years before the passage of the civil-service law, mental examinations were required of applicants for enlistment in the meteorological service. The earlier entrance examinations embraced grammar, geography, arithmetic, spelling, and penmanship. As time passed the scope of the examinations was gradually increased by Chiefs Hazen and Greely, and history of the United States was added. It has been still further broadened under the civil authorities until the following scope has been reached:

Subjects.	Weights.
Spelling	10
Arithmetic	10
Penmanship	5
Copying from rough draft	10
Meteorology	30
English composition	25
Geography	5
Algebra	5
Total	100

Since March, 1900, the age limitation has been 18 to 30 years. Prior to that date it varied. First it was 18 minimum, with no maximum limit; then 20 minimum, with no maximum, and later, 20 minimum to 45 maximum.

The reports of the Civil Service Commission show the popularity of the position of Weather Bureau observer, as indicated by the large number of persons examined for that position compared with the number examined for other scientific places paying about the same initial salary. The station force was classified in 1893. In that year, when plans were perfecting, few examinations for entrance were held. In 1894 42 persons were examined; in 1895, 44; 1896, 34; 1897, 37; 1898, 99; 1899, 230, and in 1900, 314. It will be noted that up to 1898, inclusive, a period covering five years, 256 persons were examined, while in the last two years, 1899 and 1900, the number was 544—more than double the preceding total.

PROMOTION EXAMINATIONS.

In presenting this feature, station and Central Office employees have been combined, separation being impracticable.

Of the 288 employees subject to these examinations, 105, or 36 per cent, have been examined.

The highest and lowest ratings obtained by those that passed (reexamination included) are:

	Highest.	Lowest.
Grammar	99	70
Arithmetic	100	70
Elementary meteorology	100	70
Algebra	100	73
Trigonometry	100	84
Physics	99	70
Astronomy	98	76
Botany	96	86
Advanced meteorology	97	72

The supervising examiner regards as passable in any subject a rating of 70 to 74; as fair, 75 to 79; as good, 80 to 84; and as excellent 85 and above.

The following tables will show, by subjects, the number examined, the number passed, and the number failed:

ORIGINAL EXAMINATIONS.

	Examined.		Passed.		Failed.	
	Collegian.	Noncollegian.	Collegian.	Noncollegian.	Collegian.	Noncollegian.
Grammar	55	50	47	37	8	13
Arithmetic	55	50	39	34	16	16
Elementary meteorology	55	50	53	42	2	8
Algebra	29	13	19	10	10	3
Physics	32	14	26	12	6	2
Trigonometry	12	0	10		2	
Astronomy	5	0	5		0	
Botany	5	0	5		0	
Advanced meteorology	5	0	4		1	

REEXAMINATIONS.

Grammar	3	8	3	2	0	6
Arithmetic	14	10	11	6	3	4
Elementary meteorology	1	2	1	2	0	0
Algebra	6	1	5	1	1	0
Physics	4	0	4	0	0	0
Trigonometry	0	0				
Astronomy	0	0				
Botany	0	0				
Advanced meteorolgy	1	0	1		0	

ESPRIT DE CORPS.

One of the military chiefs of the meteorological service gave it as his opinion that—

Our meteorological work all depends upon an accurate and continuous record. To get these conditions observers must be carefully trained and must be held with an absolute control. This makes a military organization indispensable.

Another army officer of long experience in both the military and civil meteorological services said:

Good soldiers, as also good civilians, do not need constant application of corrective measures. Get good men and there will be no need of military discipline. Get worthless men and all the military discipline in the world will not rid them of their worthlessness. The prime factors of an observer's make-up are obedience, honesty, and reliability.

The three factors mentioned by the latter official are preeminently the controlling factors in this Bureau.

Neither pestilence nor storms have availed to stampede the station workers of the Weather Bureau. Whenever circumstances require, we may confidently look for a repetition of that display of courage and fidelity on the part of the station force which occurred in the summer and autumn of 1897, when the dreaded yellow fever was so prevalent as to render perilous the positions of many of our men, who with great zeal and faithfulness remained at their posts, held there solely by a sense of duty to the public. The conspicuous conduct at the Galveston station on the occasion of that terrible hurricane in September, 1900, was but another illustration of what may be expected of our station force in responding to the call of duty.

When the telegraphic report of an observation is received late or not at all, the station is called on for explanation. During the calendar year 1900 more than 83,000 telegraphic reports of observations were required to be transmitted to the Central Office. During the same year but 26 calls for explanations were necessary, and less than 25 per cent of that small number of calls were unsatisfactorily explained.

This marked punctuality in the handling of telegraphic reports is as gratifying as the result of an inspection of the last semiannual report on the accuracy of work on the more important meteorological forms. Out of 173 Forms 1001, 38 per cent were literally correct; of 151 Forms 1022, 89 per cent were likewise correct; of 45 Forms 1026B, 62 per cent; of 45 Forms 1026T, 71 per cent, and of 86 Forms 1070, 64 per cent.

There are few stations that have not been inspected during the past two years, and the high commendations elicited by these inspections have greatly outnumbered the few slightly unfavorable reports.

As in the old days, so in these, an accurate, continuous, and complete system of observations and reports is easily maintained, whether based on work performed in the metropolis of the country or at the most isolated point. The marked devotion to duty of the old observer sergeant, great as it was, regardless of his location, has found its counterpart in the zeal of his civilian successor.

The older men of the Bureau will recall with satisfaction the words of the military chief who, in the name of the Secretary of War, made the formal transfer of the weather service to the Department of Agriculture. At the time of the transfer he said:

> The various duties of the Signal Corps have brought the present Chief Signal Officer, while serving as a subordinate, into unusually close relations with the enlisted force in almost every section of the continent, from the valley of the Rio Grande to the plains of the Dakotas and Montana, and in the dreary wastes of the Polar regions. Such conditions necessarily develop the character of men, and under these adverse and trying circumstances the enlisted force has invariably performed its duties with rare efficiency and fidelity, and it is with great regret that now, after over twenty years of service, covering the prime of his manhood, he severs his official relations with a branch of the Signal Corps which has been charged with duties always entailing responsibility and anxiety, fraught often with danger and hardship, and which have proved to be of benefit to the country and an honor to the Army.

If this commendation was merited, it is to be noted that 61 per cent of the present station force were then in the enlisted corps of observers and came within the purview of those remarks. Thirty-five per cent of the present force joined the Weather Bureau after its transfer to the Department of Agriculture. This blending of the old and new has yielded a body of men whose animating spirit is scarcely equaled in any other branch of the public service, and certainly not anywhere surpassed.

CHINOOK WINDS.

By Mr. E. J. GLASS, *Helena, Mont.*

Along the eastern slope of the Rocky Mountains in winter, with a temperature below zero and the ground covered with snow, a peculiar mourning or whistling sound is most welcome to the ear. This sound acts like magic on its hearers. It causes the business man to lose a moment in his calculations, the clerk to pause in his routine, and the stockman to listen intently. It announces the advent of the chinook wind. This wind is more welcome to stockmen perhaps than to any other class of business men. The stockmen know that the high velocities which generally accompany these winds will first blow the snow from the hills and high ground into the ravines, then the temperature will rise, usually above 40° F., and occasionally above 50° F., and clear the ranges so the stock can find food. The snow is drifted by the chinooks into the deep canyons and ravines. It is slightly melted on the surface by the warmth of the wind, and the water percolating slowly downward gradually converts the mass into solid ice. Unless these drifts be solidified by the thawing and freezing process they can not be depended on for summer use. Thus chinooks serve a useful purpose in the storage of the snow that supplies the water to our rivers during the summer season. The solidification of the snow by the chinook winds, by rendering rapid thawing impossible, prevents the destructive spring freshets in streams and rivers that sometimes occur when the snow lies undrifted over the hills and plains.

Three things are essential to the formation of a chinook wind, viz, a mountain range, an area of high pressure, and an area of low pressure. The area of high pressure and the area of low pressure must be so situated with respect to each other and to the mountains that the wind from the high area into the low area blows across the mountain range. If the mountains extend northwest and southeast, as the Rocky Mountains in Montana do, the direction of the chinook winds will be from the southwest or west.

At Helena, Mont., the barometric conditions accompanying the chinook are as follows, viz, an area of low pressure moving southward along the eastern slope of the Rocky Mountains, its center passing over the northeastern part of Montana; and an area of high pressure central over the region comprising Utah, Nevada, and the southern part of Idaho, the eastern edge of the high extending only to the crest of the Rocky Mountain Range. The winds of the westerly side of the low take the air from the base of the mountains, and its place is taken by air from the upper regions of the high, the mountain region holding back, as it were, the surface air of the high area. The upper region of the high area has a higher temperature than its surface air. In descending the eastern slope of the mountains, the air from the upper region of the high area is further heated dynamically. Its temperature rises to 40° F. or 50° F. and frequently remains stationary at that height for twenty-four hours. The vertical temperature gradients of the area of high pressure must increase up to a certain altitude. However, no kite observations have been taken in the Rocky Mountain districts to verify this fact. The mining town of Unionville, 6 miles south of Helena and a few hundred feet higher, is located at the head of the same gulch in which Helena is situated. Unionville has been observed on several occasions to have temperatures above the freezing point while at Helena the temperature would

be 15° F. to 30° F. below zero. During the last part of January and the first part of February, 1893, Helena experienced the coldest weather since the establishment of the station at that point. During this period of protracted cold the air was calm. On the top of the main range of the Rocky Mountains, southwest of Helena and about 15 miles distant, the temperature was above the freezing point. Another instance of the warm air being above the cold in an area of high barometer is shown by the case of one of the eastbound Northern Pacific trains. As the train descended the Rocky Mountains it experienced in traveling 10 miles a rapid fall in temperature from above freezing at the summit to 25 below zero. The change was so sudden as to cause great creaking sounds in the cars, which attracted the attention of the passengers and alarmed them, and they were not reassured until told by the conductor that they were descending into a cold wave on the eastern slope of the mountains.

The clouds usually indicate a chinook several hours before the change in temperature takes place. These clouds consist of small ragged cumulus not stratified in the least and traveling with great rapidity. They generally range themselves in parallel rows, with blue sky between. Sometimes they are black and threatening, but no precipitation occurs. (Illustrations of these cloud effects are given in Plate IX, Figs. 1 and 2.) Many times when the eastern slope of the Rocky Mountains is enveloped in the warm cloak of a chinook the States of Utah, Nevada, and Idaho are reporting zero temperatures. The temperature of the chinook wind can not possibly be classed with the warm weather that accompanies an area of low pressure, as the rise in temperature is not gradual like that accompanying the usual low area, but is sudden. The temperature often changes 20° to 30° in ten minutes, as the thermographs at stations along the eastern slope of the Rocky Mountains show.

Cold waves seldom follow chinook winds, and the temperature generally remains mild for several days or until an area of high pressure approaches from the northwest, reversing the conditions of chinook production. An area of low pressure over the plateau region and an area of high pressure passing southward from Alberta along the east slope of the Rocky Mountains is the opposite of the chinook condition, and it is without fail accompanied by a cold wave—one of considerable severity and one which continues for several days. A good example of this is shown on the weather maps of November 17 to 20, 1900. Chinook conditions sometimes form during summer, but they are of very short duration and difficult to forecast, because the area of high pressure does not remain in summer any length of time over the plateau region. A few examples of chinook conditions can be found on the weather maps of January 14 to 18, 1899; December 21 to 25, 1899; March 5 to 8, 1900; February 24, 25, 1901. These are only a few examples of the chinook winds of Montana. These dates are marked types, and the temperature changes were rapid and accompanied by high winds.

The most beautiful cloud formations are caused by the chinook. They apparently travel eastward rapidly only to disappear and others to take their places. The sky is of a deep blue and very transparent. Mountain ranges 20 miles away look as if they were only 5 or 6 miles distant. It is a quite common thing at the beginning of a chinook for the temperature to fluctuate rapidly, that is, to rise suddenly 20 or more degrees, only to fall as many degrees during the next five minutes and to continue this rapid change for an hour or more before the chinook drives out all the cold surface air.

FIG. 1.—CHINOOK CLOUDS.

FIG. 2.—CHINOOK CLOUDS.

DISCUSSION.

Mr. CLAYTON. I think the chinook is an interesting example of a phenomenon, which occurs in other parts of the United States. Of course the chinook wind is very much more marked than the others, but along the Atlantic range and probably along all elevated situations in the United States on the windward side there are slight tendencies to that effect. It is often noticeable on the weather map that it snows at Buffalo and Cleveland some time after it is clear on the Atlantic coast, the descending air being relatively both warm and dry on that side of the mountain. I think this is a good field for those young investigators we have been speaking of, because, it seems to me, it will have a bearing on the local forecasting of the section.

THE FORECASTER AND THE NEWSPAPER.

By Mr. HARVEY MAITLAND WATTS, *of the Philadelphia Press.*

Seven years ago, in discussing the relation of the Bureau to the public through the medium of the newspapers, in pointing out how uncertain a medium the newspapers were, a few practical suggestions were made as to how the situation might be improved by certain definite action on the part of the Bureau.[a] That the précis written in

[a] The communication here referred to as written seven years ago was printed in the American Meteorological Journal of January, 1895, but was written in November, 1894. After a presentation of the facts as to the neglect of meteorology by the newspapers, the suggestion was made that as so little aid could be expected from them we must look to the Bureau for a special effort at illuminating the press, and the communication then continued as follows:

"With regard to the Weather Bureau much can be done along normal lines to improve the situation. The question is hardly one of space, and, without asking for any additional space, there is a way in which the Bureau can be of service to the newspapers, and both directly and indirectly impress itself on all the matter written on weather topics. As a basis for this improved relation, as a very sine qua non, the Bureau should issue a general weather chart (about the size of the Hydrographic Bureau's monthly charts), which could be hung up in every newspaper office throughout the land. This chart should contain a large generalized weather map of the United States; not so large, however, but that enough space be left for letterpress embodying in as simple language as possible the most accurate information on weather lore as it is held to-day. Particular pains should be taken to define the ordinary meteorological terminology. Tornado, thunderstorm, hurricane, cyclone, should be carefully differentiated and explained with reference to the map, which should contain some such general and typical storm on it as the cyclone which conditioned the tornadoes at Louisville on March 27, 1890. On the map also could be shown a typical hurricane from the West Indies, with paths of others that have been charted. In the letterpress several storms could be analyzed and salient facts as to storm formation and movement presented in a lucid manner; for the most important condition of all is that it should be written from the point of view of the nonlearned reader. Such a chart, with all technical subtleties suppressed and arranged so that those who never before knew what a storm was should understand for once, would work a revolution in the average newspaper office. Instead of the blundering use of meteorological nomenclature now the rule, an exact use would set in, and with the chart ever near at hand for instant reference with which to compare some telegraphic dispatch, the general and local weather article would constantly improve. This is the first step. It would be a sort of Piddington's newspaper hornbook.

"Following close upon the chart, to the issue of which attention could be called from Washington, explaining just what the Bureau hoped to accomplish by it, there should be sent out a small pamphlet calling the attention of the newspaper to the importance of printing all the data sent out daily from Washington in connection with the nightly forecasts. Many papers print the forecasts only, but they should be urged to use also the paragraph which gives the general forecast of weather conditions the country over, which, as it locates the 'lows' and 'highs,' is invaluable for reference afterwards. In addition, the newspapers should be asked to print the monthly summaries, most valuable also for reference, and the

1894 applies all the more strongly to-day shows how small the change for the better has been on the part of the newspapers. The Bureau's work has been markedly improved, the character of the general forecast, with its summary reviewing the general conditions, has approached very near to the practical ideal which it has seemed to me should yield the best results so far as its effect on the minds of the people is concerned. Not only that, but the improvement in the explanation which accompanies the local forecast, in which the individuality of the local forecaster has been brought out, has been marked, and, as is well known, the present Chief of the Bureau is not only anxious about, but encourages in every way, such departures from the routine announcement as will make the daily phenomena under discussion more easily understood by the great public he serves. This is clearly indicated in his instructions sent out in 1899, the formal document, well worth quoting to-day, running as follows:

U. S. DEPARTMENT OF AGRICULTURE, WEATHER BUREAU,
Washington, D. C., December 19, 1899.

[INSTRUCTIONS NO. 148.]

In order to extend the value of the work of the Weather Bureau, local forecast officials, section directors, and other officials of the Weather Bureau who are authorized under existing instructions to make local forecasts will amplify the local forecasts with particular regard to local interests and the occurrence of local events.

It is desired that the local officials referred to in the foregoing paragraph feel free to express themselves in such terms and so completely as to give to the public the largest measure of benefit to be derived from the Weather Bureau.

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statement of monthly averages (Form 1079, Meteorological), which is a sort of 'monthly forecast.' Few newspapers print all these data now, and if the more important papers the country over were gotten into this procedure, as a matter of course it would be no mean reform. This is the second step in the improvement of the relations of the Bureau with newspapers; and the third step is the question of the reproduction of the weather map daily. Long before this step is taken it is to be hoped that the weather map will come into a more general use among laymen and newspaper men for reference and study, so that it will be intelligible to those who see it printed as well as to those who print it.

"So far as most maps now used in newspapers go they are glaring failures. The chalk-plate process prints a map that simply uses up space and is worthless. It is illegible and meaningless, even if one takes for granted it is understood by the public. The letterpress that accompanies it is too stilted and general in character. There are no mechanical difficulties in the way of reproducing a good two-column map in our great papers, but the trouble comes in getting a good map to reproduce. What is wanted is a distinct, legible map, with the 'highs' and 'lows' accentuated, and only the important stations shown. This is a basic condition, but above that in importance is the explanation, not wooden, which should accompany the map from day to day as it varies, and explain just what it means. There are some who declare, I believe, that no explanation is needed. That is pure fatuity. There never was a greater mistake. Looking at this matter from the inside of a newspaper office, the need of the simplest, primer-like explanation becomes imperative. Without it the map is worthless. A great deal can be said in from 100 to 300 words in small type under a two-column cut and yet not eat into space. But of course all this presupposes a closer relation of the local forecast officials and the newspapers, for some one must prepare the map and letterpress to accompany it, and it can not be done in a perfunctory way, or failure will be the result. This, then, is the third step in the better relations which should exist between the Weather Bureau and the newspapers. Many would make it the first, but one must crawl before one can run. What all newspaperdom needs is a general illumination in weather lore. The local officials do much. Their words often fall on stony ears, and yet in spite of, not by means of, the reporters they get sound weather facts before the people. If all would work together in the way here suggested, a great change would occur in a few years, and the weather articles would no longer be a reproach to the intelligence of the newspapers and a confusion to the readers.

"H. M. WATTS.

"PHILADELPHIA, PA., *November, 1894.*"

In addition to the local amplification of forecasts and the improved character of the general synopsis, which every newspaper ought to print in full, the monthly Weather Review, under the editorial charge of Prof. Cleveland Abbe and under specific encouragement of Professor Moore, has taken on a character that makes it one of the best exchanges that come to a newspaper office, since it is a mine of rich scientific material, of timely and popular interest, which only has to be properly worked by the observers to afford the public much matter of general interest and of a high educational value. While all this is true, an additional seven years' study of the situation created by the relation of the Bureau to the public through the medium of the newspapers, from the double point of view of a student of meteorology as well as a newspaper man, has merely reenforced my earlier convictions. The public as a whole has changed but slightly and is to-day practically ignorant of the fact that the science of meteorology has developed within the past fifty years a body of fact, of theory, and working hypotheses that compares favorably with any other of the natural sciences. On the contrary, the public holds to old and exploded beliefs, folk superstitions, and what not, with remarkable pertinacity, and, since with this attitude a more or less general acceptance of the claims of weather quacks and wonder mongers exists, as a consequence the difficulty of making any headway must be clear to everyone, and this is certainly brought home vividly to anyone who tries to enlighten the public through schoolroom or lecture platform.

For one thing, the terminology of meteorology conveys little to the mind of the average person. The physiographer, in talking of valleys, ravines, lakes, hills, mountains, gorges, deltas, rivers, slopes, is using terms that connote in the minds of most people definite and somewhat familiar ideas, but the unfortunate meteorologist working down from the A B C's of azimuth, barograph, and cyclone to the mysteries of hyetal phenomena and their zoonomic consequences, is in sore straits. Like the philosophers of Laputa in Gulliver's Travels, we have to carry our entire pack of terms on our backs, and can not move glibly in discourse until we have set them all down and explained them one by one to our listeners. This barrier of a not generally understood nomenclature is, of course, not made less by the prevailing confusion over such terms as the public has adopted for its own, such as "cyclone," "tornado," "hurricane," etc., and the whole situation is further complicated since the newspapers—and here I speak by the card, lest equivocation shall undo me—have failed to meet the emergency that confronts them. The rather pessimistic view taken of their intermediary relation between the Bureau and the public in 1894 must be held to-day by anyone familiar with the daily sins of omission and commission—the daily conflict of fake against facts that mark the weather article. Whatever their equipment may be in other particulars, altogether too many newspapers fail to differentiate seriously between quackery and the new science, and unfortunately rather reflect the ignorance of their own environment in the matter of weather and meteorology instead of illuminating it.[a]

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[a] This indictment may seem too sweeping, too general, but while there has been a marked improvement in the character of the special articles on the weather—scientifically accurate and at the same time "interesting"—which the better type of newspapers occasionally print, and while the list of newspapers that represent equipment in this particular is constantly growing, at the same time the errors that occur in the reportorial and editorial treatment of routine weather phenomena are much in excess of what one would expect, considering the accessibility and essential simplicity of the undisputed facts of modern meteorology.

The situation thus created, therefore, by the conditions that exist to-day is an anomalous one and makes the work of the Bureau, despite the admirable efforts of everyone in it to serve the public faithfully, unnecessarily difficult. Being what it is, however, I feel that the plan I suggested in 1894, with certain modifications, still promises the best results, and if rightly applied will meet the state of things that exists in the average newspaper office to-day. And of all the various issues that confront the Bureau to-day none is so fraught with possibilities for good or ill as the use of the newspapers. While the public may be reached in other ways on occasions, it is the daily newspaper's constant, reiterated presentation of the weather three hundred and sixty-five days in the year that is the determining factor in the status of the Bureau with the public. The pressing fact is that without act of Congress or administrative order the daily newspaper is the unofficial agent of the United States Weather Bureau. The question, therefore, is not how the public may be made to grasp the new meteorology through other channels, but how the newspaper can be made the medium of an equipped, illuminating presentation of the weather facts as we know them. What is demanded by the rather unfortunate state of things that exists to-day is an improvement in the work of the unofficial factor in the intercourse between the Bureau and the public—between those who reflect the modern science and those to whom it is still a mystery. No radical improvement can be made in the use of the newspaper, however, unless some adequate idea be gained from the inside as to the actual needs of the average newspaper. A ten years' study of a wide range of exchanges has but doubled the conviction that the improvement of the newspaper as a medium of instruction for the public must proceed along very simple lines. Certain newspapers to-day will print anything, but the only special publication on the weather that tells is that that clears up the matter in hand in such a way that, if the reader never understood the issue before, he will understand it after reading the given article or studying the given map. If the work of the Bureau in this direction is to tell more effectively to-day, "stoop to conquer" must be the motto for all those in its service who come in contact with the public through the newspaper—and this means the newspaper reporter nine hundred and ninety-nine times out of a thousand—and I shall indicate the lines along which I think this policy can make itself felt with greatest practical effect.

I still believe that the Bureau should issue a general informatory chart—the details of which I need not discuss—for use in newspaper offices, to say nothing of its value to public schools. If the issue of such a chart by the Bureau seems irregular and the expense not warranted it can not be too firmly said, in view of the actual, if unofficial, agencyship the newspapers occupy as a vehicle of intercourse between the Bureau and the public, that no stone should be left unturned to add to the equipment of these inexperienced agents who multiply its influence a thousandfold. The Bureau exacts a high rate of service from its forecasters, and it is continually planning for their increased efficiency, such a convention as this at Milwaukee being an evidence of the thought and effort and money expended on the improvement of the official personnel. But if the unofficial personnel, which is no less a part of the Bureau's system, even if unrecognized by law, be overlooked, the very efficiency of the regular force will find itself hobbled and hampered in its endeavor to reach the public in whose interest the whole service is created. There is, therefore, to my mind, ample justi-

fication for any direct and instructive appeal to the newspapers through some special Government publication. But in lieu of any such issue there are certain practical reforms in the matter of the relation of the forecaster and the newspaper that are at the command of any observer in any station.

In the first place it must be remembered that by reason of the exigencies of newspaper service while the newspaper remains the same the reporters form a shifting medium as far as individuals go. What is done for one man one day has to be repeated for another man the next day; for too often the pressure of news, the balance of the office personnel, and other contingencies make it impossible for the most careful city editor, or news editor, or managing editor to assign the same man to write the "weather story" week in and week out. Many newspapers make an effort to develop special men, but the forecaster or observer who depends on the special "weather man" of any given newspaper will be apt to find that just when he most needs him a newcomer will be apt to appear in his place, the specialist having other duties to perform.

In the second place it is fatuous to take for granted either that the public or the newspaper can be fed on technical matter or matter stated in technical language. All that is suggested for newspaper publication should be lucidity itself, and as simple as the exact use of the ordinary vocabulary will allow. Any technical terms that are used should be carefully explained, and great care taken always to use the same terms in their exact scientific sense, particularly in cases where journalistic and public error have confused and confounded them. This primer-like simplicity of statement can not be too strongly insisted upon. Moreover, if lived up to, it serves the double function of teaching the observer to formulate his ideas in a clear and convincing manner, as well as illuminating the public through the work of a well-drilled reporter and a self-drilled forecast official.

In the third place, the forecast official or observer in any given station should not view the daily or occasional conference with reporters as in any sense an intrusion on the office routine, but as one of the most important functions his office discharges in its relation to the public. He should map out for himself a consistent scheme of weather and meteorological explanation; should prepare himself specially to be ready, on any given emergency in the way of a recurrence of familiar weather types that are repeatedly the object of public interest and newspaper discussion, to give an interesting account of just what the situation means, and what the causes are and what the effects will be.[a] This may seem formidable, and to call for more time than the forecaster has at his disposal; but if the matter is taken up progressively through the year the observer will find as he prepares himself on one phase of the weather after another that in twelve months he has run over practically all that is needed, and all he has to do in the future is to fall back on the material he has provided, with such incidental references to the weather of the day under discussion as differentiates it from its general type. As to details, I would suggest, for instance, that so simple a thing as the monthly summary (Form 1030), which usually arrives at most newspaper offices now a day late, on the 2d of the succeeding month, should be gotten out in time to be sent to

[a] An example of high-class effort in this direction was the issuance by the Chicago office, under the direction of Professor Cox and the special service of Mr. Walz, of a luminous account of hot waves and high temperatures prepared for printing after the close of the hot-wave period for June–July of this year (1901).

the morning newspapers on the night of the last of the month, that its bald table of fact should be prefaced by a running account of the peculiarities of the month as compared with other months, all written in as free and as interesting a way as the observer can command. Of course, the preface should not be left until the last hours of the last day, but should be prepared at leisure, notes being made as the month goes on, and should be ready in the afternoon of the last day, only needing the final data to release it. Prof. A. J. Henry, of the Washington office, has made the very practical suggestion that the monthly summary (Form 1030) and the monthly table of averages (Form 1079) be issued together. If this be done, the running account can be made to combine a survey of the past month with a forecast of possibilities, as it were, in a way that can not but be entertaining, and it goes without saying that newspapers that shy at the bald, uninviting table will print such a monthly article with avidity. As it is, many newspapers often try to write a general article themselves, using the data received, and do it rather haltingly, so that there is a chance here for an observer to make himself personally felt in an important particular of his work.

But, aside from so regular a thing as the monthly summary, there is the eternal question of the hot and cold waves, the thunderstorm, the mild spells, the droughts, wet weather, explanations of which phenomena the newspaper is continually reaching out for. If in its efforts to obtain explanations of these phenomena the newspaper is given the dreariest routine information by the observer, the disposition is to treat the matter in a sensational, or, as it is called in newspaper offices, in an "interesting manner," in sheer self-defense. Here is, indeed, the forecast official's opportunity. Let him prepare himself, in writing, to give the essential facts as to causation as it is revealed in the Weather Bureau brochures on all the phenomena he is called on to discuss with reporters. The matter should take the form of a concise statement that is not too dry, even if scientifically accurate. Let him prepare these articles, written, as the year develops, on one phase of the weather and another from January to January. They should be typewritten, so as to be easily duplicated as often as wanted. Then when a hurricane is approaching, or a given region is tornado struck, let him give to the reporters these summaries of the facts as to the causation in issue of the tropical cyclones or in the formation of violent local rotary storms, explaining by reference to the daily map the precise situation that exists on the particular date in question and the specific relation of the given actual phenomena to that that has occurred before. If this be done for all the important phases of weather that visit any given locality; if the observer always has his material handy for comparisons of, let us say, the heaviest rainfalls, the longest droughts, the highest hot-wave maxima, the percentage of inaccuracy, and the foolish, bewildered muddlement that is too common a feature of newspaper accounts of weather phenomena to-day will be reduced to a minimum.

It will probably occur to many that the so-called "means" book, planned by Professor Henry, and now a matter of office routine, to a certain extent affords a record that could be utilized for the purposes herein noted. This is true, but my concern is that the forecaster keep this informatory reference matter not as an official record, but merely as a personal convenience in the issue of his relation to the newspapers. Hence his collection of material can take on a freer form, and, in addition to books and Government reports as a nucleus, I would suggest the use of large envelopes, classified under general

titles according to the Dewey, or any other system, which envelopes may be filled with matter from any source bearing on the subject called for, and which envelopes will form an easily get-at-able scrap-book collection, constantly increasing in volume as time flies and additions are made to the collection. The writer has found that stout manila envelopes, 10½ inches by 7 inches (which are large enough to hold the Government bulletins and monographs), indexed on their flaps, afford the most convenient method of classifying and keeping weather data. They take up little space, are easily handled, and a well-filled envelope under any given head, such as "thunderstorms" or "hurricanes," represents a maximum of detailed information with a minimum of inconvenience as to its immediate availability. The pasted scrapbook is a wasteful, unsystematic method of collecting or keeping data, and is particularly objectionable when it comes to the question of turning over any given data to a newspaper for special use. At first the available data may seem incomplete to the local station man, observer, or forecast official, and as for his own précis or abstractions of special articles, or summaries of comparative research along a given line, they may seem to him at first very unsatisfactory. Indeed, it may not be, will not be, easy for the observer at first to write special articles just as he would like to see them, but facility will come with trial and experience, and one year's effort will revolutionize his relation to reporters—and this means to the community—and he will thus not only increase his personal usefulness to the Bureau, but will enhance its value greatly in the eyes of the public.

It should also be remembered that in preparing articles to cover specific weather occurrences many an article can be made to tell in signal style if it be accompanied by a carefully prepared map. And in this matter of map making, I wish to say that just as the public and the newspaper are unprepared to-day for the undiluted technical weather article, so are they unprepared to understand the daily weather map unless it be simplified on publication and be accompanied with the most lucid explanation. The regular daily weather map itself reduced in size, if reproduced with all its data in the newspaper, is a Chinese puzzle, and of doubtful value, since its complications are meaningless to the average reader, and not being understood, rather repel him, and the map signally fails in its purpose. As a piece of routine, I am not in favor of the daily use of the map in the newspapers, but I am a firm believer in the use of a special map on occasions when the public mind is ready for it, owing to the special interest in some phase of the weather, when the map can be made to tell the story of weather causation in a striking and positive manner in a way that gives what words can not convey, and is a direct reenforcement of the text.[a] Such a map requires, however, the active cooperation of the forecaster in its preparation, and he must be quick to see what feature shall be accentuated in order to reach the general reader and teach him a needed lesson in meteorology, as well as be within the grasp of the newspaper men themselves. But even such a map loses most of its value unless the explanation that accompanies it really explains, and is written from the point of view of one who realizes what the public does not know, but should know. Printed anyhow, merely for the sake of printing a map, the result is pointless,

[a] An idea of the kinds of maps that are most effective in newspapers is given in the selected group of weather maps which originally appeared in the Philadelphia Press, and are reproduced as to map and text as an appendix to this article.

and advances neither the interests of the Bureau nor dynamic meteorology one whit; but rightly used the occasional map can accomplish an important work. It allows an important weather fact to be driven home, as it were, and affords a unique chance for special studies in weather contrast to be made; and when presented at the right psychological moment, so far as the public is concerned, has a high educational value. What is more, the newspapers will use maps whenever they see there are pith and point in them.

But aside from the amplification of the daily forecast, the writing of occasional articles, and the preparation of occasional maps, a good stroke for meteorology and the Bureau can be made by calling attention to special articles in the Monthly Weather Review, which, if they are too long for reproduction in full in the newspapers, might be conveniently summarized or abstracted; for, although the Monthly Weather Review is an excellent publication for a newspaper to have on its exchange list, at present only a few newspapers make use of it, and yet that its articles are appreciated is evidenced by the way in which some one article copied into a leading newspaper will make the circuit of practically every important newspaper in the country.

This may seem to pile up the agony of work on the forecaster above all endurance, but in a given year my suggestion might only call for him to work out a dozen explanations, to suggest the use of half a dozen maps, and to rewrite one or two articles from the Monthly Weather Review. In view of the enormous importance of the better relations that I am sure could be established with the newspapers and the public by doing these things, the game, I think, is worth the candle. And, in conclusion, I do not want to be understood as believing there is serious shortcoming in the work of the local forecasters or the station men in general. On the contrary, of the two factors that play their part in presenting weather data to the public, the forecast officials, observers, and the newspapers, it is the forecast officials and observers who are a monument of painstaking patience under irritating and trying conditions, and it is the newspapers that too often fail in their duty, and in so failing make it so very difficult for the forecasters, observers, and Bureau employees generally, be they never so earnest or devoted, to straighten the matter out and make headway in the instruction and illumination of the public. There is, I hope, a turn in the tide; the new generation receiving a better education in physical facts will revolt at obscurantism, the newspapers will have to take a new tack; but I am convinced that the Bureau itself in a few years could work a complete about face if definite attention were given to the improvement of its relations with the newspapers and to the illumination of the average newspaper office along the lines here suggested.

APPENDIX TO "THE FORECASTER AND THE NEWSPAPER."

As an example of what can be done to drive home a specific lesson in causation, and also in order to illustrate the pointed occasional use of weather maps, simplified for newspaper publication, half a dozen examples of maps that have appeared in the columns of the Philadelphia Press are inserted. These maps are not especially picked maps, but represent the kind of map the Press prints when there is some occasion for using a map. It has been my method on the Press to utilize any given incident in the way of acute storm phenomena, or special climatic effect, or any incident in the news of general interest, such as the international yacht races, election day, etc., as an occasion for using a map if the meteorological conditions are clean-cut and are really significant. These maps are always very much simplified and vary from time to time in the matter of the particular meteorological feature that is accentuated, the one object being, however, first, last, and all the time, to make the subject as clear as crystal to the average reader.

Exhibit No. 1 was published on June 30, 1901, and represents in its simplest form the mechanism of a hot-wave circulation for the Central and Middle States and New England. There are occasions when a larger section of the United States must be included to make the conditions clear, but as a rule the smaller the section reproduced the better, the entire map of the United States only being reproduced when it can not be avoided. As will be noticed in this case, the idea is to give the readers a lesson in hot-wave causation. This lesson of June 30 was followed by a more definite example of how hot waves are caused, by the reproduction on July 2, 1901, of the weather map of July 1 about the time that the hot wave in the Eastern States had reached its maximum. This map is shown in Exhibit No. 2 as it was republished eleven days later in conjunction with the cool-weather map of July 12, 1901, to set out one of the most beautiful contrasts in weather causation which it is possible to see in summer in the Eastern or Atlantic Coast States. As must be clear to the dullest, on the map published on June 30, and on the map of July 1, republished on July 13, there is a south-to-north circulation from the subtropics, from out the barometric high pressure (anticyclone) into the barometric low pressure (cyclone) to the north. So long as these respective aerial eddies or barometric pressures maintained the relation shown on these maps the hot wave persisted, but the reversal which set in on July 11, and is specifically revealed on the map of July 12, published July 13, gives a marked circulation from the subpolar anticyclone (high pressure) over the lakes into the subtropical cyclone (low pressure) off Hatteras, with a consequent north-to-south circulation of the winds and cool weather for New England, the Middle States, and the Atlantic littoral as far south as Georgia. The hot-wave mechanism in the Mississippi Valley, it is true, remained unchanged, as a high pressure over Texas kept up a south-to-north circulation in a low-pressure area in the Northwest over the heated interior, and did this for more than a fortnight longer. But the map the Press used was only intended to explain the movement and the weather within the vicinage of the Middle States, and all other features were ignored.

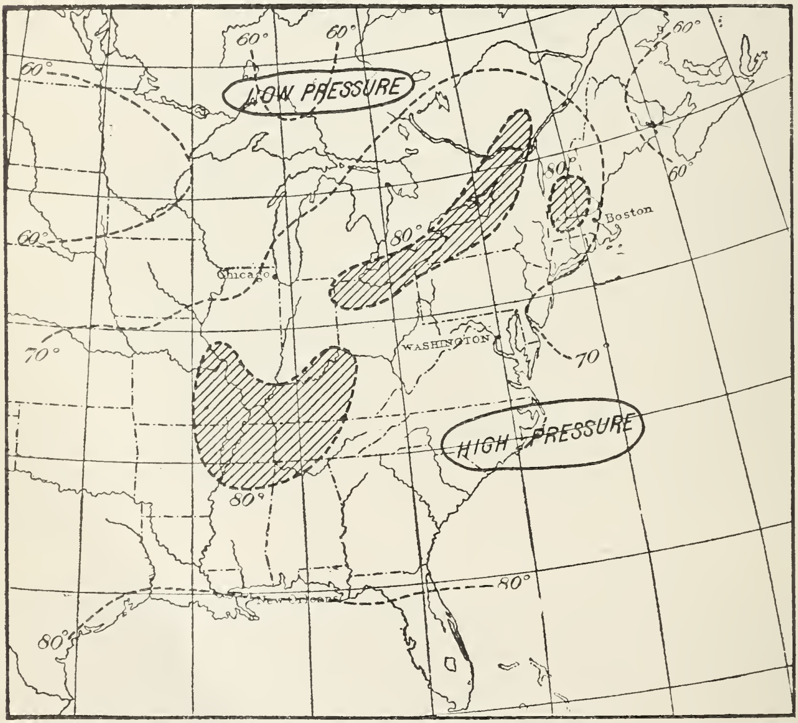
In Exhibit No. 3 an example is given of how to use the weekly crop report map. Here only the maximum temperature areas are reproduced, but as these mapped out the region of the greatest devastation to the crops, the map had a special significance, and the confusion of lines, which of necessity marks the official map with its minimum as well as maximum lines, was avoided. In the winter time, after the rule of a cold wave, a map of minimum lines is most instructive and timely. Again, whenever the opportunity arises for accentuating the difference between the general cyclone and the local violent outbursts, squalls, thunderstorms, tornadoes, etc., it is worth while doing, since no terms are more confused than the exact use of cyclone and tornado. No one, of course, who ever looked at the weather map of the United States of March 27, 1890, and saw how the general continental cyclone covered with its wind circulation two-thirds of the United States, reaching from the Atlantic to the Rockies, from the Gulf to Lake Superior, could ever again confuse it with the tornadoes which it set up in Tennessee, Kentucky, and Indiana, since even if the latter outbursts were represented by dots they (the dots) were too large in relative size in comparison with the great general storm movement as revealed on the map. To show that, though destructive, local outbursts are short lived and insignificant local eddies, a map such as Exhibit No. 4 is useful, as it serves to beat home the facts as to the relation between a general cyclonic circulation and local phenomena, just as Exhibit No. 5, the map showing the Galveston hurricane (tropical cyclone), which was printed on the morning of Sunday, September 9, having been drawn and printed hours before the news of the great disaster was sent over the country, plays an equally important part in fixing the average reader's ideas as to the relation of the rotary circulation of winds in a cyclone and its translatory movement along its path as an eddy of enormous magnitude.

The movements of great general cyclones are always very instructive, and nearly every year there is some particularly marked case of one perfect in its typical circulation and weather covering a large part of the country with its storm phenomena that is worth reproducing, just as the occasional perfect anticyclone in the early fall, winter, or early spring makes an excellent exhibit of the effects of the opposite or clear-weather type of eddy. While the anticyclones of November 5, 1900, were not such perfect types of circular eddies as are sometimes seen, still it has been the wont of the Press, whenever the weather preceding election day is marked in character, to print an informatory map and so aid in making the daily forecast and probabilities of election clear. Exhibit No. 6 was published on Tuesday, November 6, 1900, the day of the Presidential election. It was headed, for picturesque purposes, "Republican Weather To Rule." but maps and lines were intended to convey a lesson in meteorological causation and weather drift, and, as will be remembered, the "clear weather" forecast was justified by the halcyonic conditions that prevailed the country over.

These six maps here republished can easily be improved upon, and all that is claimed for them is that they were published from no aimless desire "to have a map," but with a definite, equipped purpose in view each time. As reproducing or redrawing the regular daily United States Weather Bureau map and selecting the special features calls for special effort, it might be wise for the Government to issue a black and white map in outline, upon which any features from the daily map could be traced by the local officials with ease, which maps could then be reproduced by the newspapers without redrawing. The present daily weather map, which is about 10 by 7 inches, is too faint in color and too small in proportion for use directly. In general, it may be said that all the green, blue, and brown inks used in Government maps are unsuitable for direct reproduction. The situation calls for a map of the United States with black lines on a white ground, at least 12 inches across from California to Nova Scotia, and 9 inches from Canada north of Lake Superior to the Gulf at Havana. Such a map in blank, if accessible at every station, would simplify the problem very materially, both for the newspaper and the local forecast official. As the question of space, as well as meaning, is ever a pressing one in newspaper offices, it is worth noting that Exhibits 1, 4, and 5 are facsimiles of "two-column cuts," which size the Press has found meets the map needs in most cases, while Exhibits 2, 3, and 6 are reductions of "three-column cuts." But, after all, in addition to the map, one must have definite ideas and a method in reproduction, and above all a letterpress with each map that tells what it is there for in a way to catch and interest the casual reader.

Exhibit No. 1.—*The blanket of summer heat.*

[From the Philadelphia Press, June 30, 1901.]



The weather conditions prevailing at 8 a. m. yesterday, as shown on the United States weather map, were very similar to those that set in early in the week. They were the familiar conditions peculiar to a hot wave and offered slight prospect of a radical or immediate change. These conditions were in the nature of an area of high barometric pressure over the Southern States and a low pressure over the lakes. This caused a sluggish circulation of wind from the South to the North and was responsible for the general hot wave with its various pockets of overheated areas, the temperatures prevalent at 8 a. m. on the map representing areas that later in the day gave maximum temperatures from 15° to 20° higher.

EXHIBIT No. 2.—*Contrasts in July weather.*

[From the Philadelphia Press, July 13, 1901.]

(Weather conditions, 8 a. m., July 12.)

(Weather conditions, 8 a. m., July 1.)

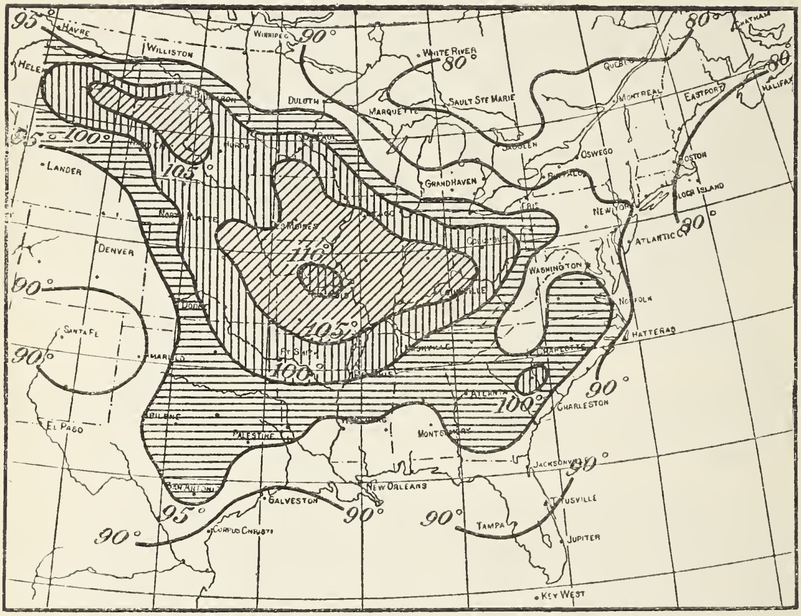
The cool weather of yesterday, as the 8 a. m. map of the United States Weather Bureau makes clear at a glance, was due to a north to south (northeast to southwest) circulation from out an area of high pressure (barometric) over the lakes into an area of low pressure off the Carolinas. Not only the weather but the circulation was thus in absolute contrast to that which prevailed on July 1, which represented the typical hot-weather state of things, the winds, as the second map shows, moving from the tropical South to the North from a high-pressure area over the Carolinas to a low pressure over the lakes. So long as the high pressure remained to the south of the Mid-Atlantic and Central States the hot wave of last week continued in force.

The first break in this hot-weather type of circulation occurred on Sunday, and since that time the pressures over the South Atlantic coast have been relatively low. Yesterday, however, revealed the most definite change from the hot-weather conditions of a week ago, and in consequence the New England States, the Middle States, and the northern tier of Southern States enjoyed what was a cool circulation from the north and from the oceans, and the tropical circulation was beaten back toward the south and southwest. The most decided effects of this cool-weather circulation were, however, confined to the Eastern States, the hot wave in the Mississippi Valley and the extreme South being little affected.

As the region shaded in yesterday's map shows, the 80-degree line at 8 a. m. ran up as far as Missouri. This meant high temperatures of 100 or so later in the day, as there could be no let-up in the Mississippi Valley hot wave, since it was controlled by a circulation moving from the South into a low-pressure area over the extreme Northwest (not shown in the map), and was too far away to be modified by the north to south circulation that prevailed over the Eastern States from Michigan to Maine and from Canada to the Carolinas. As the winds blow in and about the low-pressure area in cyclonic fashion, and as the area itself moved to the northeast, the coast and coastal States experienced a typical ocean storm, with rain, on-shore winds, and a high surf.

Exhibit No. 3.

[From the Philadelphia Press, August 1, 1901.]



With the great drought in the corn belt of the middle Mississippi and Missouri Valley States broken, apparently for good, the weekly map of the climate and crop division of the United States Weather Bureau, showing the conditions that prevailed during the culminating week of the drought, July 22–29, possesses special interest. The map, reproduced in the Press to-day, shows the extent and location of the regions of maximum temperatures for the week in question. These lines of highest temperature map out very accurately the sections where the drought was the severest, the line of 105° F. covering very nearly the corn-growing region, with Columbia, Mo., centering an area, with a diameter of 100 miles or so, where the temperatures reached the 110° level for the maximum and never went below 70° for the minimum. In this pocket of overheated territory the minima were often above what would be the normal maxima for July, and on some days the mean temperatures were over 95°.

Moreover, although this map only represents the conditions for the last week of the drought, there was so little material change in the reign of the hot wave over the Mississippi-Missouri Valley States for the month that it gives a fair idea of what these sun-baked regions experienced for thirty-one days. The first week in July saw the region about Columbia, Mo., for instance, with maxima of 105°, while the 100° line covered the main corn belt, with an isolated patch of 100° lying over the coastal region of the Middle States, Philadelphia's maximum being 103°. After that week cooler weather prevailed generally in the East, and though the week ending July 15 saw an enormous extension of the 100° line in the Mississippi Valley and the Gulf States, with Columbia, Mo., the center of the 110° patch, the Eastern and Middle States escaped the worst. There was no let-up in the West, however, and the map for the week ending July 22 saw the line of 105° covering a large part of Missouri and Illinois and small sections of Nebraska, Iowa, and Wisconsin, while the 100° line for the week ending July 22 covered almost all of South Dakota, Wisconsin, Nebraska, Kansas, Oklahoma, Arkansas, Missouri, Illinois, Indiana, Ohio, Kentucky, and Tennessee. The area is very nearly the same in extent as the 100° line of the week ending on Monday, as is shown by the map. Of the average yield of 2,100,000,000 bushels of corn grown in the United States, about 800,000,000 bushels are grown in the area covered by the 105° line in the map, with Columbia, Mo., as the center, and it was in the area thus mapped out that the heat for the month of July was the most severe and unintermittent and the rainfall the least.

EXHIBIT No. 4—*The rule of cyclonic weather.*

[From the Philadelphia Press, August 16, 1901.]

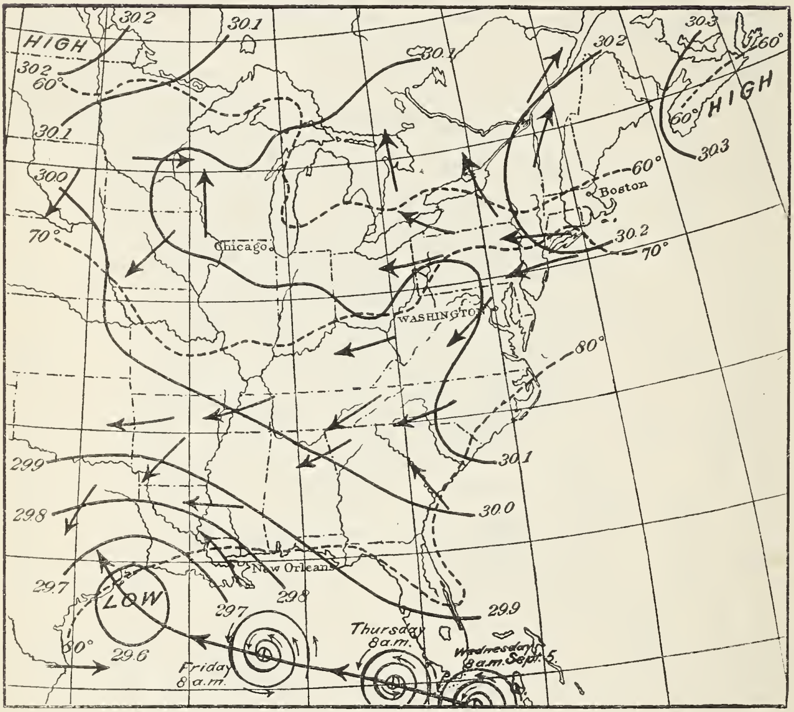
The United States Weather Bureau map representing conditions at 8 a. m. yesterday revealed the eastern half of the United States controlled as to its weather by two areas of low barometer, which, according to invariable law, are the seat of a cyclonic circulation. The low area, or general cyclone, over the lakes in its passage eastward was marked by the formation of local disturbances, thunderstorms, squalls, and small tornadic outbursts, one of which, accompanied by an extensive thunderstorm, passed over southern Philadelphia and Camden. These disturbances usually occur in the southeast-to-south quadrant of the general cyclone, from 300 to 600 miles from its center. Consequently, yesterday local storms were set up in the morning in Indiana, Ohio, and Michigan, and as the center of the general cyclone moved eastward toward evening it was in a favorable position to superinduce local disturbance in southern and eastern Pennsylvania and the vicinity of Philadelphia.

The lake cyclone confined its influence to the upper half of the country east of the Mississippi Valley, while the Gulf coast and Gulf States were under the influence of the Gulf cyclone, whose center has been nearly stationary for three days, in consequence of which its winds have raised some high tides in the Gulf, and, judging from the latest reports, the losses to property in New Orleans and Mobile by flood may be followed by loss of life on the low-lying islands of the Louisiana and Alabama coast. These islands are but little above the ordinary high water, and many of them are used as summer resorts. While the winds and cyclonic tides have done the worst damage along the coast, the heavy cyclonic rains have done some damage in the interior, although up to last night the storm had shown slight inclination to move inland.

Both cyclones show the peculiar inward circulation of the winds about the center, and reveal their great area, as compared with the small but violent local disturbances which the northern one set up on its southern edge, and which, if indicated on the map, could only be represented by a dot.

EXHIBIT NO. 5.—*The track of the hurricane.*

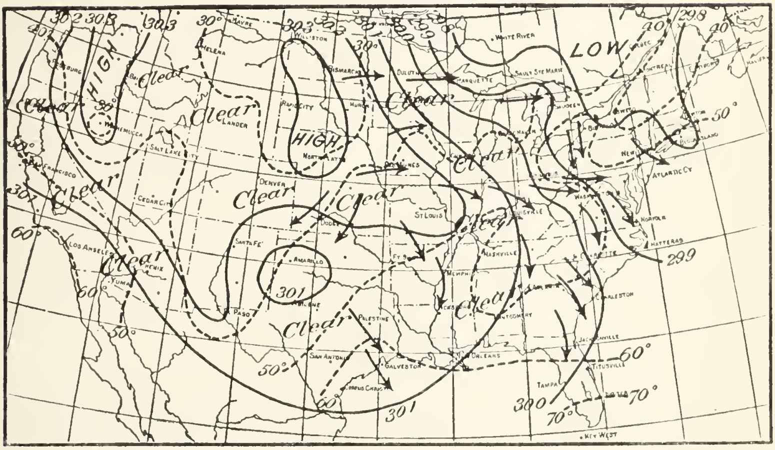
[From the Philadelphia Press, September 9, 1900.]



The path of the average tropical hurricane, while seemingly subject to amazing vagaries, really varies very little. Those that move over the West Indies, near or north of Porto Rico in August, recurve in the Bahamas and, turning northeast, move up the coast often parallel, but little by little turning to the east and "going out to sea." Those that recurve over or just west of Florida follow the coast line more nearly and are very apt to take in every town from Pensacola and Jacksonville to Boston and Portland, Me., and give them a taste of heavy rains and high winds. The September cyclones usually recurve near Florida. The United States Weather Bureau map of 8 a. m. yesterday indicates the cyclone (shown by the area of low barometer) just moving inland from the Gulf. Its high winds and high tides, due to the winds, seem to have done considerable damage on the low-lying Louisiana coast line. As the storm advances inland it often loses all its energy, and its track, which then tends northeast and may carry it up the Ohio and St. Lawrence valleys, is made manifest only in excessive rains, but not in gales or dangerous tempests. As the map makes plain, Philadelphia and vicinity was not affected by the cyclonic winds, but by an easterly and northeasterly circulation moving out of an area of high barometer (anticyclone) over New England. This type of circulation gives a damp, but practically stormless nor'easter, often without rain at all, and with very light winds. It is only when the northeast wind is flowing into and about a low barometer (cyclonic) that it means a gale.

Exhibit No. 6.

[From the Philadelphia Press, November 6, 1900.]



This map of the United States represents the weather conditions as reported by the United States Weather Bureau at 8 o'clock yesterday morning. Since the weather drift in the United States is from west to east, conditions that are prevalent on the Rocky Mountain slope one day repeat themselves farther eastward the next day, and the weather of the Mississippi Valley tends to duplicate itself over the Central and Middle States within twenty-four hours. The "highs" and "lows" on this map refer to barometric pressures, not to temperatures, the solid lines inclosing regions of the same barometric pressure, while the dotted lines connect the points that have the same temperatures. The "high" areas are the seat of pressures above the normal of 30 inches and are in consequence a center of dispersion for the winds, which move down and out from a "high" spirally in all directions. This descent of dry and relatively cool air makes the "high" the center of clear-weather phenomena, while the "low" area, where the winds concentrate and ascend, is the center of stormy weather. On the map yesterday two separate "high" areas, one east and one west of the Rockies, gave over three-fourths of the United States clear weather. The eastern "high," which was central over the Dakotas and Nebraska, conditioned the winds and clear weather all the way to the Atlantic coast. As both "highs" will drift east to-day, they promise to continue fine weather from the Pacific to the Atlantic, as the "low" area, with its clouds central over northeastern New England yesterday, will have passed east to Newfoundland, and in its place a very steady high pressure, true American weather, should cover the entire length and breadth of the United States. The temperatures promise to be moderate and the winds light.

VALUE OF THE CLIMATE AND CROP AND STORM WARNING SERVICES OF THE WEATHER BUREAU TO THE INDUSTRIES OF CUBA AND OTHER ISLANDS OF THE WEST INDIES.

By Mr. M. W. Hayes, *Havana, Cuba.*

The United States Weather Bureau maintains a complete chain of observatories from Port of Spain, Trinidad, to Havana, Cuba. During the hurricane season daily 8 a. m. observations are telegraphed from all of the West Indian stations to Havana, the headquarters of the West Indian forecast district, and certain morning reports are received from the United States. All these reports are charted immediately, and a study of the existing conditions made.

As a rule no public forecast is made unless disturbed or stormy conditions exist. Should the charted reports indicate threatening weather, but show no marked storm, this information is communicated to the marine interests. Storm or hurricane warnings, when such warnings are demanded by the charted conditions, are telegraphed immediately to the islands likely to be affected, and to such other localities as the marine and other interests render advisable.

The method adopted for the systematic distribution of warnings is to divide the West Indies into specific sections, and make each Weather Bureau station, and also the United States consular offices at St. Pierre, Guadaloupe, St. Thomas, and Port-au-Prince, subdistributing points for its particular section.

Telegraphic facilities are fairly good throughout the West Indies. To every island that it is possible to reach by wire, when threatened by a hurricane, there is telegraphed by one of the subdistributing points a plainly worded warning of danger.

Sometimes it is preferable to take even more active steps than the display of flags to disseminate information of a very urgent nature; and, again, frequently the information is intended solely for the benefit of vessels ready to leave port and need not be communicated to the general public (as it might cause unnecessary alarm); hence each subdistributor has a carefully conceived plan for the handling of the various kinds of information sent to him. The general method followed is for the subdistributor to advise marine interests, Government officials, and repeat the message to all United States consular or other officials in his section, and these officials in turn give it the publicity the circumstances may demand. When a hurricane is predicted a special effort is made to display the signal on flagstaffs which can be seen by passing vessels, enabling them to seek timely shelter.

On nearly all the islands the Government officers, on the receipt of an emergency warning, take active measures to give the information as wide circulation as possible. In order to accomplish this end, use is made of the telegraph and the telephone; also mounted messengers are sent out, and signals are made by firing cannons and rockets.

When one considers that the largest number of the inhabitants of the West Indies live in houses that are none too stable, also the innumerable small sailing vessels engaged in interinsular trading, fishing, and sponging, and the many large sailing vessels and steamships plying between the Antilles and the other ports of the civilized world, one appreciates the value to these interests of judicious warnings. Such warnings enable the inhabitants to take all possible precautions to reduce the loss of life and the damage to property to a minimum, and the vessels, possible to reach, to seek a safe anchorage. The attitude of the executives and other high officials of the various islands is

an evidence of the esteem in which the forecasts are held and the confidence placed in them. These officers make energetic efforts to have warnings spread throughout their jurisdiction, and especially to have them reach isolated points, exposed rural communities, where many lives are at stake, and ports where the small sailing vessels frequently enter.

The Weather Bureau warnings have held in port the large passenger steamers plying to and from the West Indies, as well as the pleasure yachts, and the small interinsular sailing vessels. It is indeed a pronounced recognition of the value of our warnings to have vessel masters that have been sailing in tropical waters for long years, and who naturally have a rather high opinion of their knowledge of the storms of that region, to remain quietly at anchor, despite their desire to sail, so long as they are advised that they would incur the risk of encountering a hurricane.

While the value of the service to the islands of the West Indies is great, it is all incidental, in a way, when we consider the benefits of this branch of the weather service to us at home.

By having the West Indies observatories, the Weather Bureau can watch the hurricanes from their inception or appearance, and by following the storms as they move through the West Indian region and issuing advices in regard thereto, the public and shipping in the United States likely to be affected by hurricanes are not subjected to the great financial losses common in the days before the establishment of this particular service of the Bureau.

The Cuban section of the climate and crop service of the Weather Bureau was organized in the early part of 1899. Previously no successful governmental or other systematic effort had been made to locate meteorologic outfits throughout the island. Observations, however, have been made with more or less regularity at scattered points in Cuba.

The most important industry of the island is agriculture. As the intimate relations between climate and agriculture are universally recognized, it is not surprising that those who volunteered to make observations when the United States Weather Bureau offered to place instruments at selected and well-distributed points belonged to Cuba's educated class. I think I am justified in saying that no climate and crop section of the Weather Bureau has a corps of voluntary observers of a higher degree of excellency than has the Cuban section.

At present, observations are made at 39 points, uniformly distributed over the island. The meteorological observations, together with a summary of the observers' remarks on matters relative to climate and crops, are published monthly in English and Spanish. Every Tuesday there is published, in English and Spanish, a weekly bulletin on the condition of the crops as affected by the weather. The matter upon which this bulletin is based is furnished by a large corps of voluntary reporters, composed of planters and others directly interested in the subject. These reports are forwarded by mail or by telegraph.

The prestige now enjoyed by these publications is gratifying. Lengthy extracts are published by the newspapers, and a large mailing list is required to meet the demand for the reports made by the Cuban public and by interested persons in the United States.

The Cuban planter, on account of the genial climate and the wonderful fertility of the soil, is generally enabled to raise exceedingly profitable crops. He is ever on the alert to make every possible improvement, and he fully appreciates the necessity of reliable climatic data in connection with agricultural operations. To him authen-

tic temperature and rainfall data, linked with reliable and intelligible notes on crop progress and conditions, are invaluable.

The climate and crop reports are also used extensively in the efforts being made to further develop the island. Naturally the first information sought by homeseekers or those contemplating the placing of capital in Cuba is about its climate. The voluntary observing stations of the Weather Bureau so thoroughly cover the island that they give a most comprehensive knowledge of the weather that prevails at any given point.

The two crops one always associates with agricultural Cuba are sugar cane and tobacco. However, numerous other crops are raised, and still greater diversification is possible. Steps are already being taken in that direction, and to them climatic data are important from their beginning to their termination.

VALUE OF THE CLIMATE AND CROP AND STORM-WARNING SERVICES OF THE WEATHER BUREAU TO THE INDUSTRIES OF PORTO RICO.

By Mr. G. Harold Noyes, A. B., *Boston, late of San Juan, P. R.*

In considering what the benefits of the climate and crop and storm-warning services of the Weather Bureau may be to the industries of Porto Rico, it may be well to note the type of weather that obtains there.

Porto Rico is 18° north latitude and 66° west longitude, and is surrounded by a warm, deep ocean. One of the greatest ocean depths lies just north of Porto Rico, where the soundings show a depth of some 5 miles of water.

The temperature of the ocean surface water near the shore of Porto Rico is about 78° F. This maintains a controlling influence over the mean temperature of the lowland near the shore. The mean annual temperature of San Juan is 78°. The strong easterly trade winds carry the ocean temperature over the island. The island, being very small, does not develop atmospheric conditions of its own. The temperature of the island is practically constant, there being a difference of but 8° between the highest and the lowest monthly means.

Precipitation is very variable—excessive and frequent or light and occasional. Heavy, quick showers will fall from an almost clear sky, and again the most frowning clouds will give no rain. The rainfall varies from 140 inches on the windward shore of the island to 50 inches in well-sheltered leeward districts.

These figures exemplify in one way the value of the climate and crop service. Our voluntary observers have enabled us to find out what the climate of Porto Rico is. Prior to the establishment of our service some few persons took observations, but when the section director sent out a circular letter requesting copies of any weather records that might have been kept he was answered by the one man that replied to the circular, "that meteorological accounts could not be expected from people that did not keep even an expense account." Interested Americans and Englishmen began to ask about the rainfall of different parts of the island; engineers and sugar men, especially, desired to know the averages and extremes of precipitation. Some sugar planters prefer a dry locality and eke out the proper amount of moisture by irrigation; others consider a wet locality better, and trust to good fortune not to have their plantations washed away by a deluge. Some few hotel men have sought information as to temperature,

but they are usually disappointed. It is perhaps unfortunate that the mean daylight temperature for the whole year is above 80°, and this with a relentless sun and humid wind.

It is difficult to estimate the value of the climate and crop monthly and weekly reports to Porto Rican interests. There is no such thing as competition; the condition of one man's crops does not at all disturb another who raises the same product. Americans that control large estates value the reports for their representative character and accuracy. The greater part of the masses, it must be confessed, pay no attention whatever to the reports. They can't read. They perform all the labors incident to farming with a machete. They are not educated up to the fact that the reports are of value, and they will not be for some generations yet to come. We must consider that we in the United States raise crops in the most modern fashion possible, and take advantage of the climate and crop reports as being necessary to the best interests of agriculture. But in Porto Rico methods are primitive; crops are put in and if they fail from lack of attention, such as being choked by weeds, or washed out by torrential rains from want of proper ditching, the planters shrug their shoulders and complain of fate. So we see how difficult it is to ascertain how much value the climate and crop service is to the large number of the islanders at least.

The newspapers publish extracts from our reports with frequent *irregularity*, and never give proper credit to their source until very urgently requested to do so.

The storm-warning service in Porto Rico keeps the marine interests informed as to unsettled or threatening weather in the zone of tropical cyclonic development. At times the post, telegraph, telephone, horseback rider, and runner are used to warn everyone that it may be possible to reach of the approach of a hurricane. It is thankfully to be said that the hurricane signal does not have to be often displayed; but when it is the effect is a stampede. Buildings are tied down to the ground, doors and windows barred, and, indeed, every precaution is taken to forestall as far as possible the fearful consequences of a catastrophe, the fatalities of which are all too well known. Vessels seek cover in some deep but sheltered harbor, and even then may be wrecked with all anchors down and full steam up. The value of the storm warning in Porto Rico is unquestionably great.

When the hurricane signal was hoisted in the island the first and, thus far, the only time there was some scoffing by native "amateur meteorologists:" for, "How could Americans know anything about tropical hurricanes, having been here such a short time?" But the warning was so timely and the justification so absolute, that now almost any American red flag will have the effect of the *bona fide* hurricane signal. When the usual red flags are hoisted over the military rifle range for target practice the telephone rings, and terror-stricken inquiries are made as to the (supposed) approaching cyclone.

Unsettled conditions that are liable or likely to develop into definite storm centers are reported at once to persons at every port having marine interests at stake. Thus vessels are kept in port instead of being caught at sea in a storm. It is to be much regretted that the power of a tropical hurricane is so great that its destructiveness will ever be enormous. Tropical vegetation is of such delicate and weak structure that a wind of but little more than ordinary force will cause great destruction. Houses are not made with any degree of strength in tropical climates, so that any of the storms of the intensity such as recur week after week in temperate latitudes during winter would

level them to the ground. Our hope is to have the people so prepared that they can protect themselves from the violence of the storm, and being forewarned not suffer so much as would be the case were there no storm warning issued. Marine interests are the ones most helped by the warnings issued in Porto Rico. It is a matter of comforting assurance to a shipmaster to know that there is no disturbance threatening, or if there is, just where it is. So it is that the climate and crop service assists in the increase of agriculture, construction, etc. The storm-warning service guards against the sudden surprise of destruction.

The issue of a daily weather map during the hurricane season at San Juan, based upon observations taken at West Indian stations, would prove of undoubted value, especially in connection with the information message from the forecast center. Frequent inspection of voluntary and display stations is necessary, and the custom of the island requires that most formally polite courtesies and etiquette be maintained at all times. This end can best be had by having some resident native who is expert in Spanish and English as a permanent member of the service, either as clerk, observer, translator, or interpreter. This would to a large degree prevent the discontinuity of method when a change occurred in the incumbency of the office of section director. Every aid in administration of the service adds to its effectiveness, value, and prestige.

DISCUSSION.

Mr. J. L. Cline. Some things regarding the climate and crop service of Porto Rico not mentioned by Mr. Noyes I think it may be of interest to call attention to. The island is only 40 miles wide and 100 miles long, and we have 38 voluntary climate and crop stations now in operation. In regard to publications, I will state that just prior to my departure arrangements were made with the Boletin Mercantil to publish the climate and crop bulletins in full, with headings as published in the official issue, and, besides, the synopsis will appear in the San Juan Daily News. The manager of the French railway, the only railway operating an independent telegraph line, arranged to distribute free all warnings received from Havana over his company's wires. He said, furthermore, that they were of so much value to him that he would not only distribute them free over his telegraph lines, but would instruct his employees to post them at the different stations along the railroad.

THE WESTWARD MOVEMENT OF THE DAILY BAROMETRIC WAVE.

By Mr. Oliver L. Fassig, Ph. D., *Baltimore, Md.*

The publication in the later volumes of the annual reports of the Chief of the Weather Bureau of the hourly values of barometric pressure at a large number of stations in the United States, in the West Indies, and along the north coast of South America affords an excellent opportunity for the study of the diurnal variations of the barometer over a wide area. Reliable hourly observations in the middle and higher latitudes of South America are still few in number. However, by selecting for study the month of July, during which the heat equator is thrown farthest to the north, this lack of data in the

southern hemisphere is largely remedied. During this month there is a nearer approach to similarity in the distribution of land and water to the north and south of the heat equator; hence the conditions which largely influence temperature and pressure changes are more nearly comparable in the western hemisphere than they are over the eastern hemisphere, where the northern half is mostly land and the southern mostly water.

Until recently the question of the diurnal variations of the barometer has been studied mostly by means of the diurnal curve at isolated stations. In the present treatment of the subject the hourly values, or rather the hourly departures from the average for the day, at about 50 stations have been charted, after being reduced to a common hour, namely, seventy-fifth meridian time. In this way we obtain a view of actual conditions of pressure at the same instant of time over a wide area, similar to that of our daily simultaneous weather charts. Charting the observations in this manner brings to light some relations hitherto but vaguely recognized in the theoretical discussions of the subject.

In the accompanying charts (see plates X to XXXIII) I have plotted the departures from the average daily pressure for each hour of the day at stations in North and South America and in the West Indies, together with a few outlying stations. Lines were then drawn connecting stations having equal departures from the accepted normal value for the day, i. e., isoabnormals of pressure. The area covered by the observations extends from 0° to 140° longitude west of Greenwich; in latitude from 60° north to 40° south.

Taking up the charts in the order of time, the three most striking features within the area of observation are—

(*a*) The development and westward propagation of an area of pressure above the normal, an anticyclonic area, or perhaps it may more properly be referred to as a wave of increasing pressure, over the North and South American continents during the forenoon, followed by—

(*b*) The development and westward propagation of an area of pressure below the normal value, or a cyclonic area, during the afternoon, followed by—

(*c*) A period of comparatively uniform distribution of pressure during the night hours, which upon further study may be subdivided into two minor periods, namely, a secondary period of high pressure during the first half of the night, followed by a secondary period of low pressure during the second half of the night.

A closer study of the charts under consideration reveals the following characteristics of the primary and secondary anticyclonic and cyclonic systems:

(*a*) *The primary anticyclonic system.*—The area of pressure above the normal of the day appears upon the eastern coast of the United States between 5 a. m. and 6 a. m. It increases in extent and strength to 11 a. m. (seventy-fifth meridian), when it reaches a maximum, in July, of about +0.040inch over the United States, of about +0.020 inch over the Gulf of Mexico and the West Indies, and a maximum of +0.040 inch over the South American continent about an hour earlier. At the time of maximum development it extends from about 20° to 140° longitude west of Greenwich, and from about 70° north to 60° south latitude, the axis of the wave being in a NW.-SE. line through the center of the continental areas of the western hemisphere. The last traces of the area pass beyond the Pacific coast of the United

States about 4 p. m., the entire area passing a given meridian in about eight hours.

(*b*) *The primary cyclonic area.*—The primary area of low pressure immediately follows the primary area of high pressure. It appears upon the eastern coast of the United States about 1 p. m., attains a maximum development in the United States at 6 p. m. (seventy-fifth meridian), with a departure of −0.040 inch, and leaves the Pacific coast between 11 p. m. and midnight, the entire area passing a given meridian in about eight hours. Over South America it attains its greatest depth of about −0.060 inch at 5 p. m. (seventy-fifth meridian). In geographic extent, at the time of greatest development, the diameter measures about 8,000 miles, being equal in area to the anticyclonic system. The cyclonic development is greatest over the central continental areas.

(*c*) *The secondary anticyclone.*—The primary cyclonic area is followed during the first half of the night by a secondary area of high pressure, feebly developed over the North American continent during July, but quite well marked over the colder southern continent. Its greatest development is attained between 10 p. m. and 11 p. m. (seventy-fifth meridian), when it covers the entire South American continent and adjacent portions of the Atlantic and Pacific oceans and the eastern portion of the United States. The maximum departure is about +0.030 inch. In geographic extent it has about one-half the area of the primary cyclone or anticyclone.

(*d*) *The secondary cyclone.*—The secondary area of high pressure is followed by a secondary area of low pressure. This is equal in geographic extent and in the degree of its development to the secondary anticyclone, and is most evident about 4 a. m., when it prevails over all of South and North America, with a maximum depression of about −0.040 inch.

The position of the centers of the diurnal departures of pressure depend upon the season of the year and upon the relative distribution of land and water.

The westward propagation of the four areas is represented diagrammatically as follows in fig. 3, but is more clearly shown by Plates X to XXXIII.

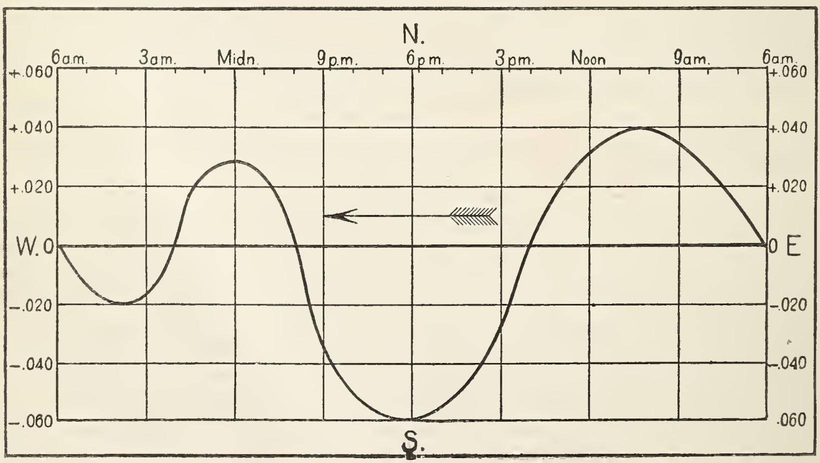
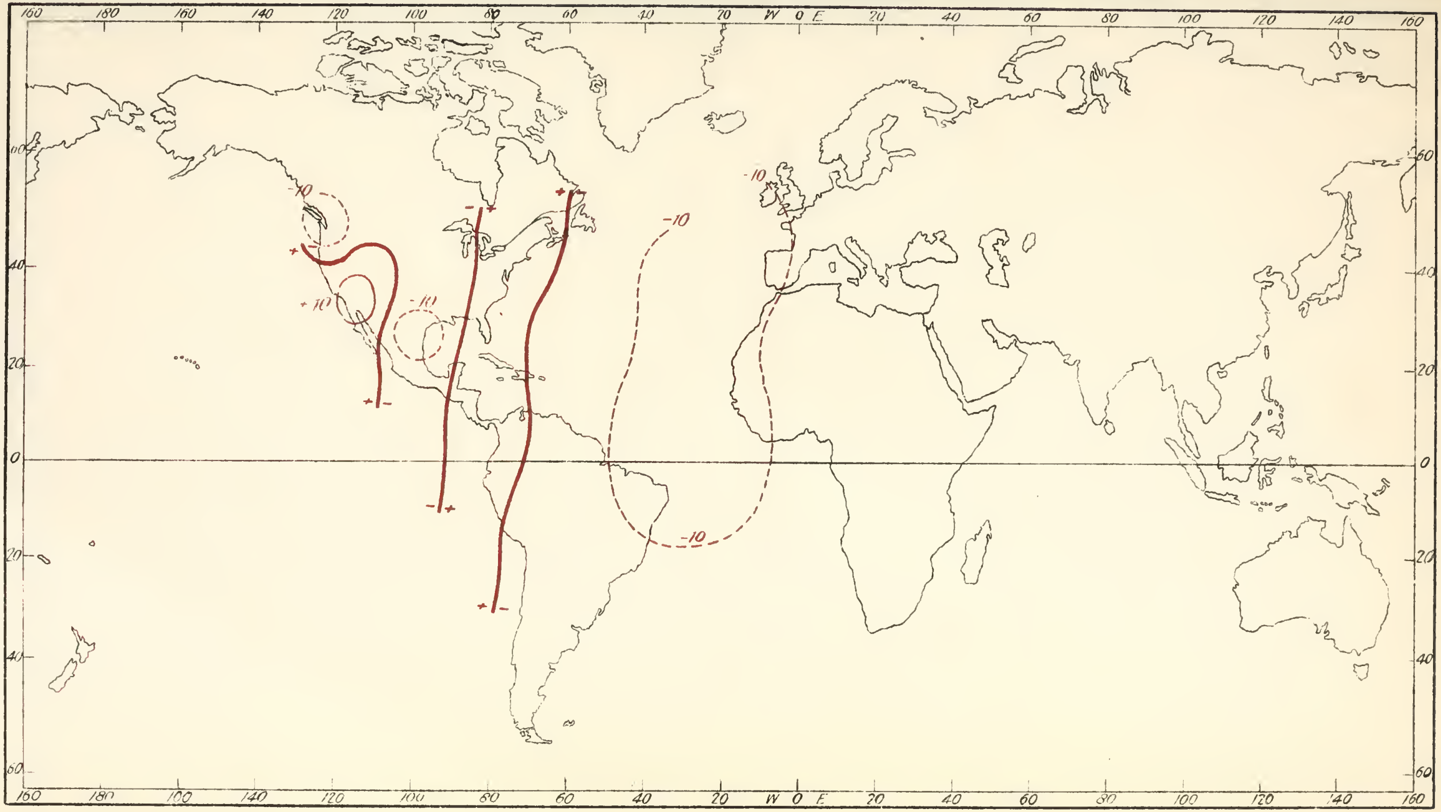


FIG. 3.

Plate X. Diurnal Westward Movement of Barometric Wave. 1 A. M.

1 a.m.



2-a.m

Plate XI. Diurnal Westward Movement of Barometric Wave. 2 A. M.

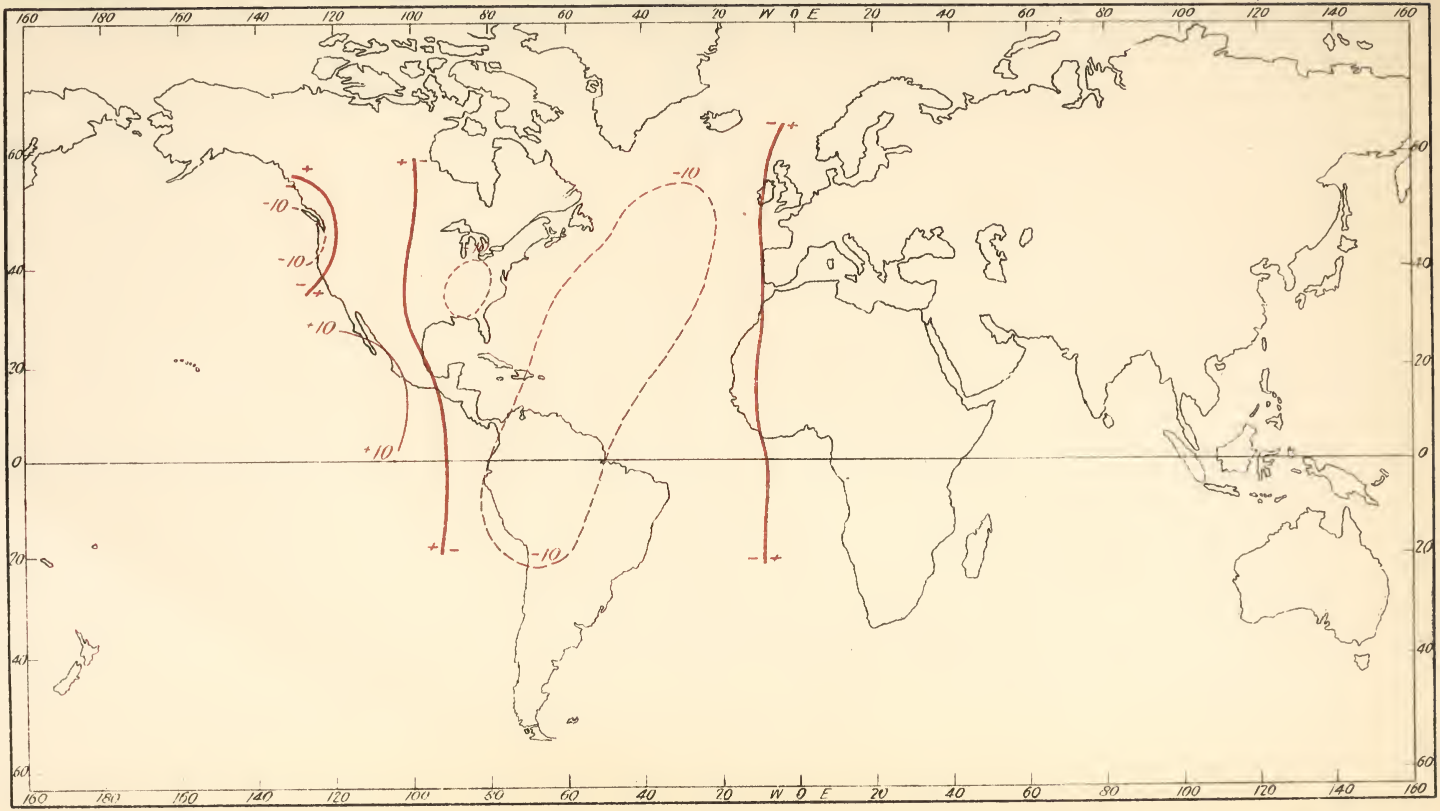


Plate XII. Diurnal Westward Movement of Barometric Wave. 3 A. M.

3-a.m.

Plate XIII. Diurnal Westward Movement of Barometric Wave. 4 A. M.

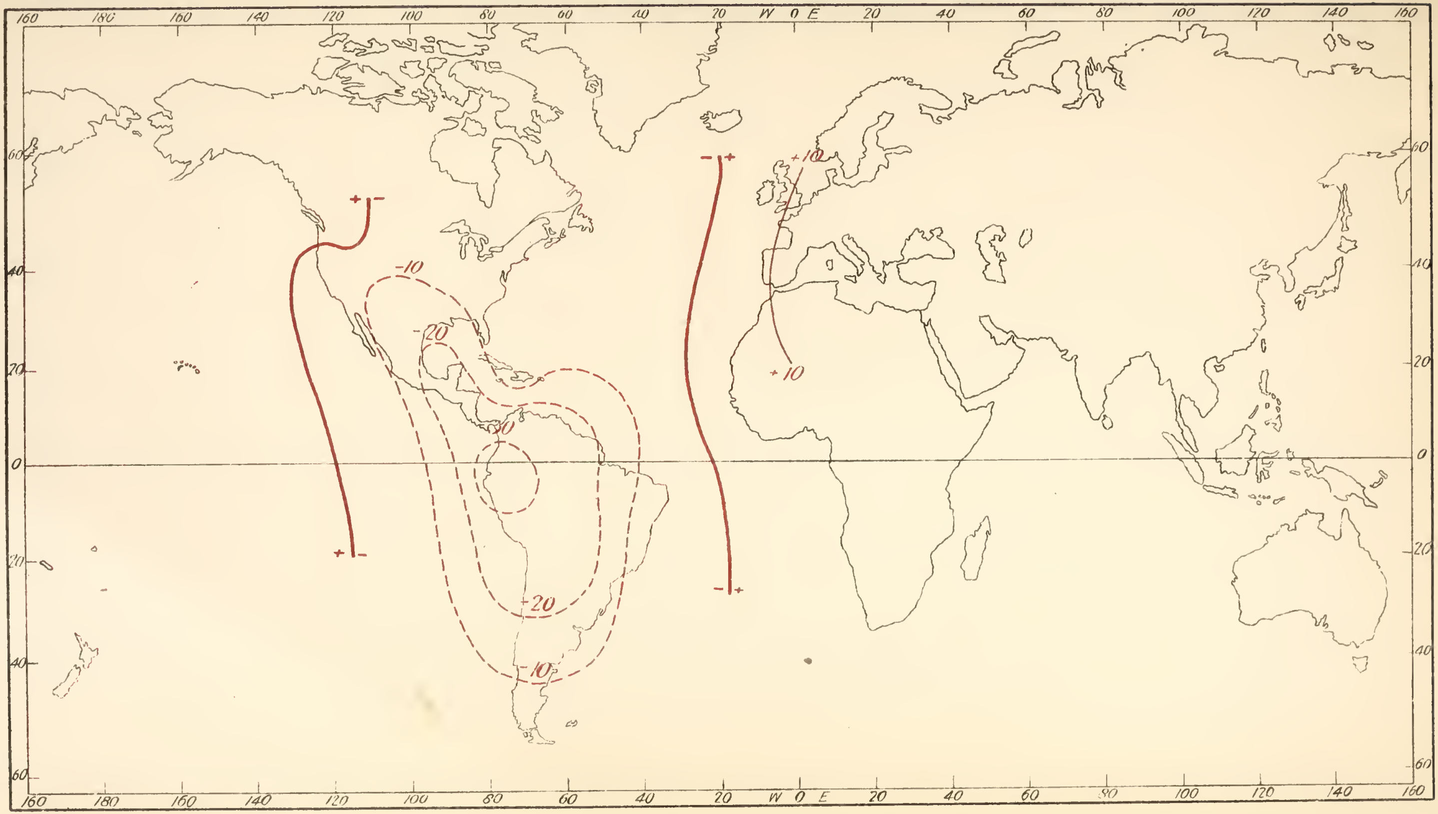


Plate XIV. Diurnal Westward Movement of Barometric Wave. 5 A. M.

5 a m

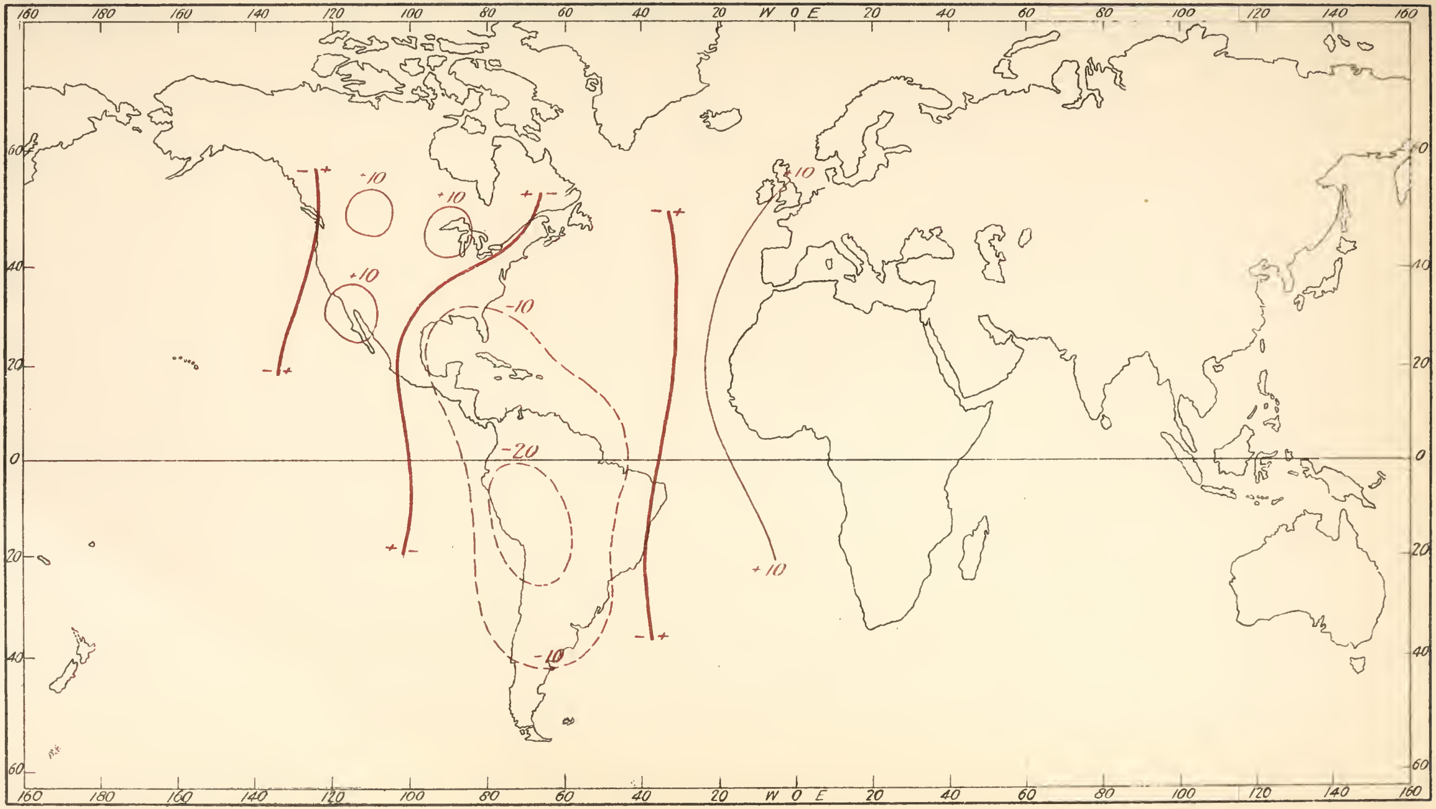


Plate XV. Diurnal Westward Movement of Barometric Wave. 6 A. M.

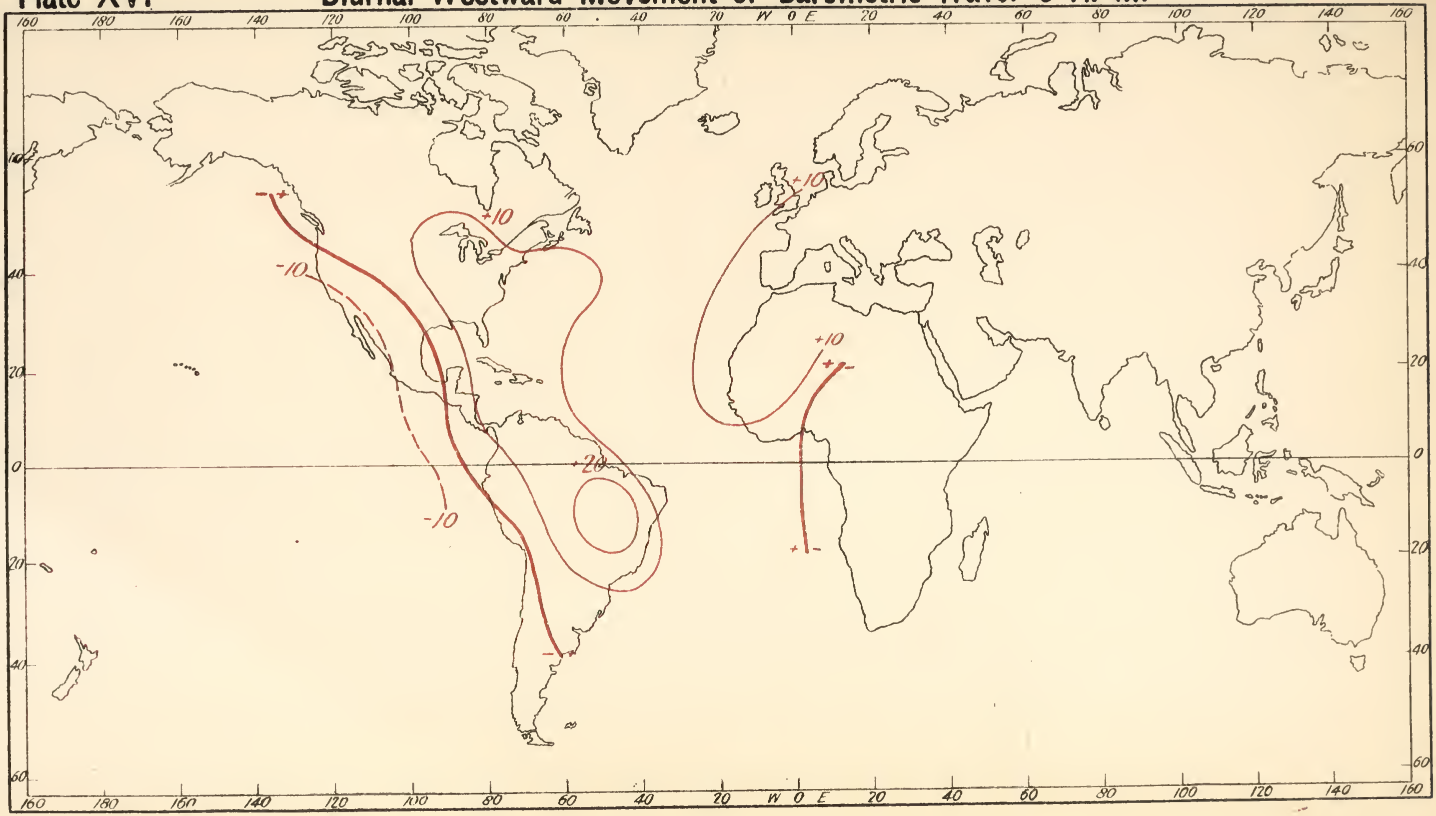


Plate XVI. Diurnal Westward Movement of Barometric Wave. 7 A. M.

7 - a.m.

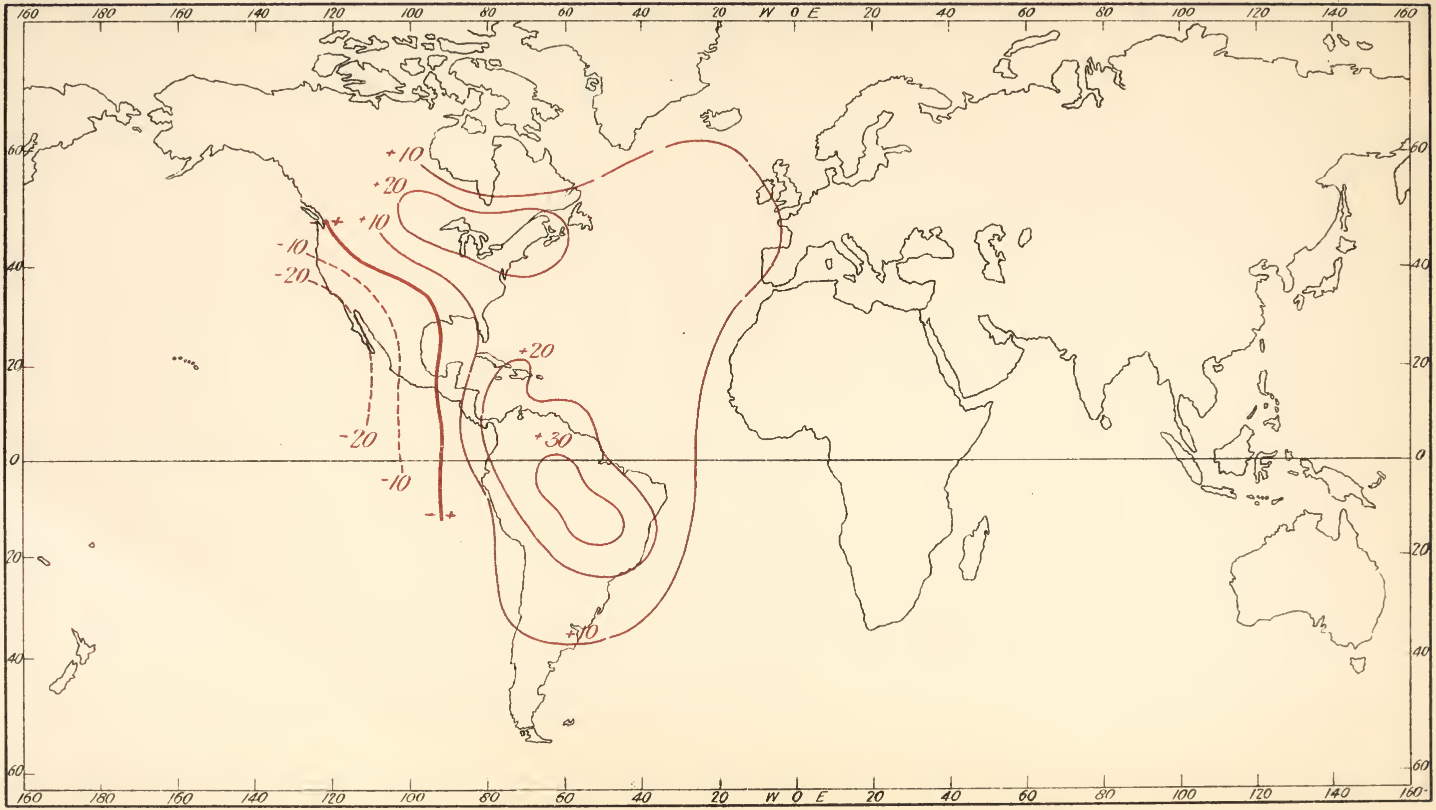


Plate XVII. Diurnal Westward Movement of Barometric Wave. 8 A. M. 8-a.m.

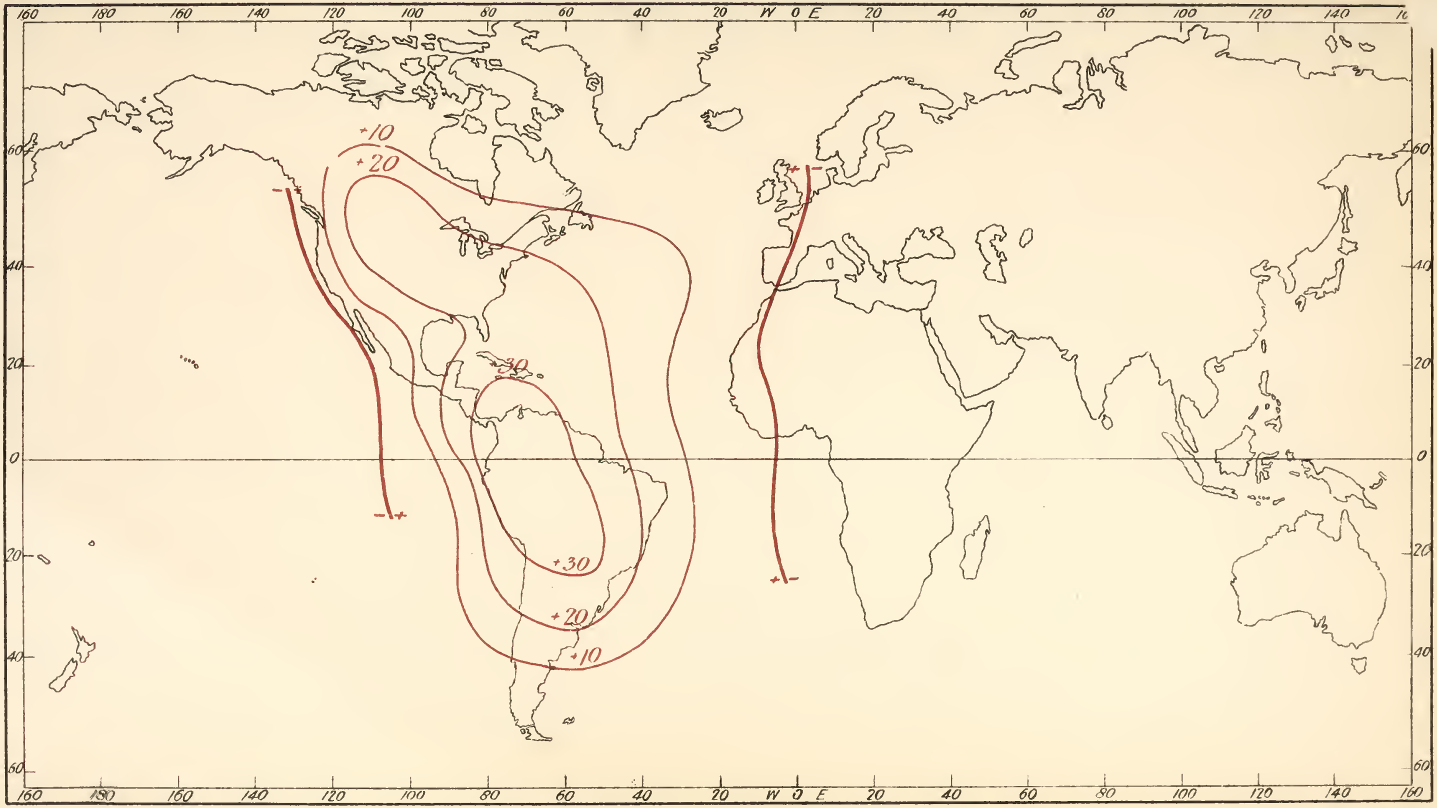


Plate XVIII. Diurnal Westward Movement of Barometric Wave. 9 A. M. 9-a.m.

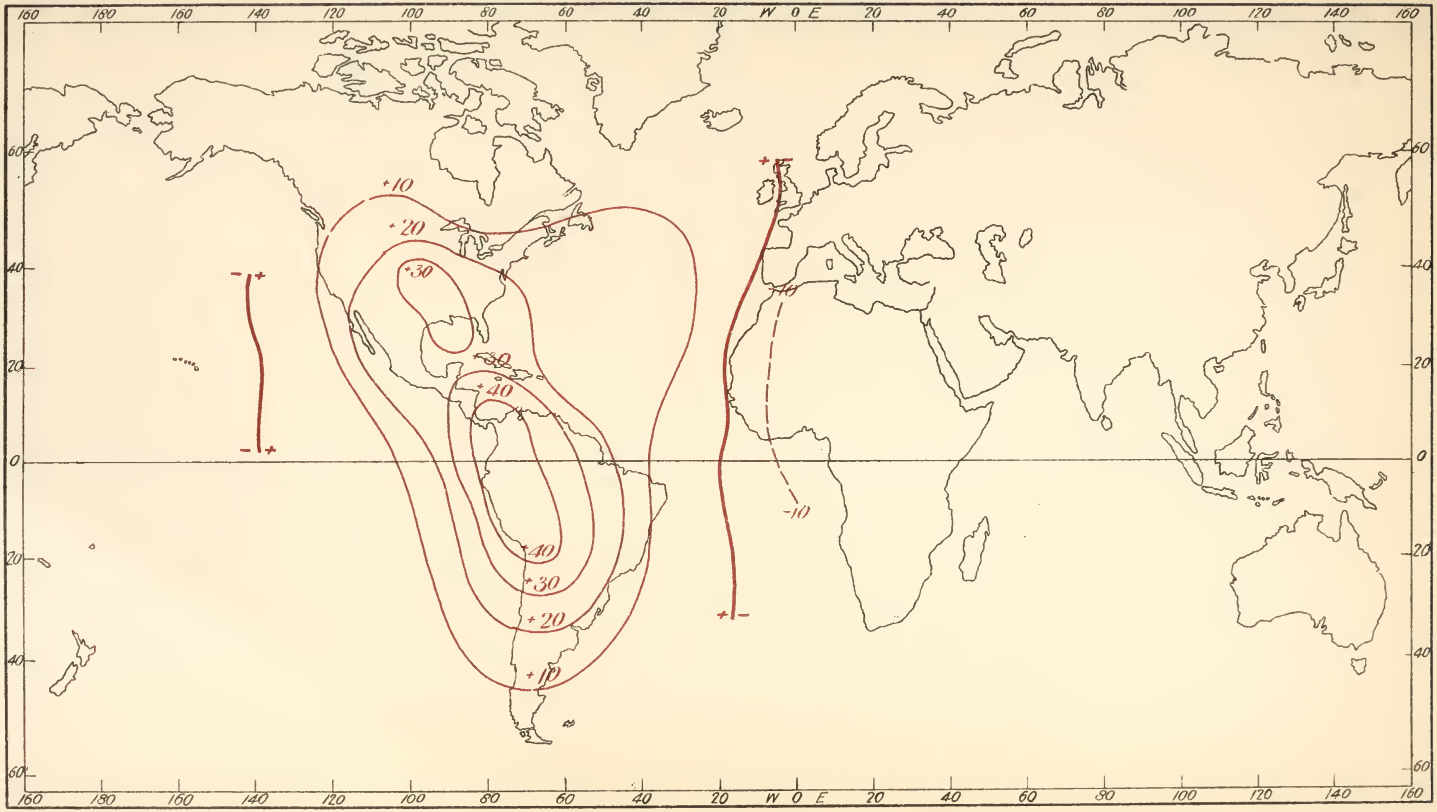


Plate XIX. Diurnal Westward Movement of Barometric Wave. 10 A. M. 10-am

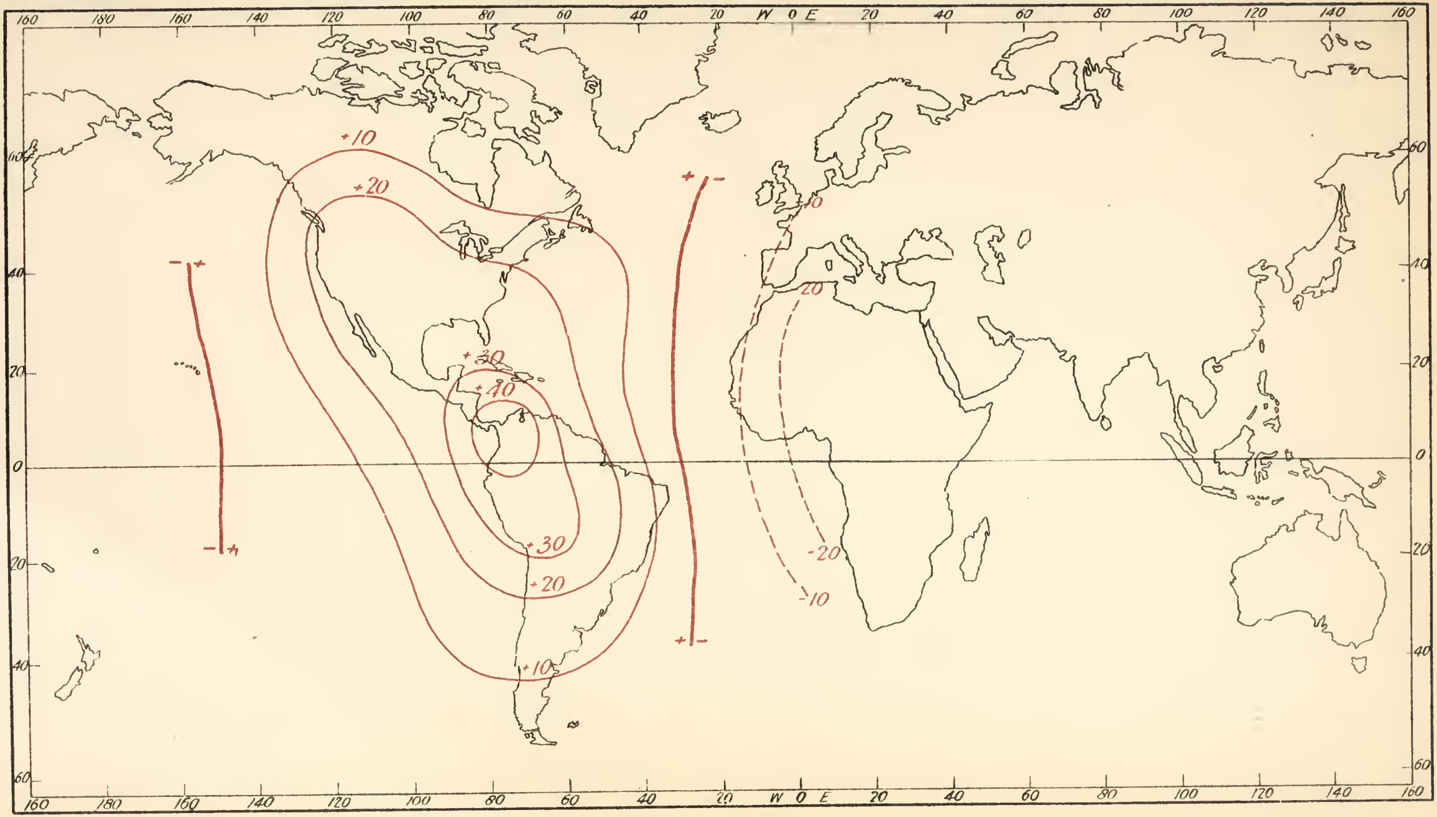


Plate XX. Diurnal Westward Movement of Barometric Wave. 11 A. M. 11-a.m.

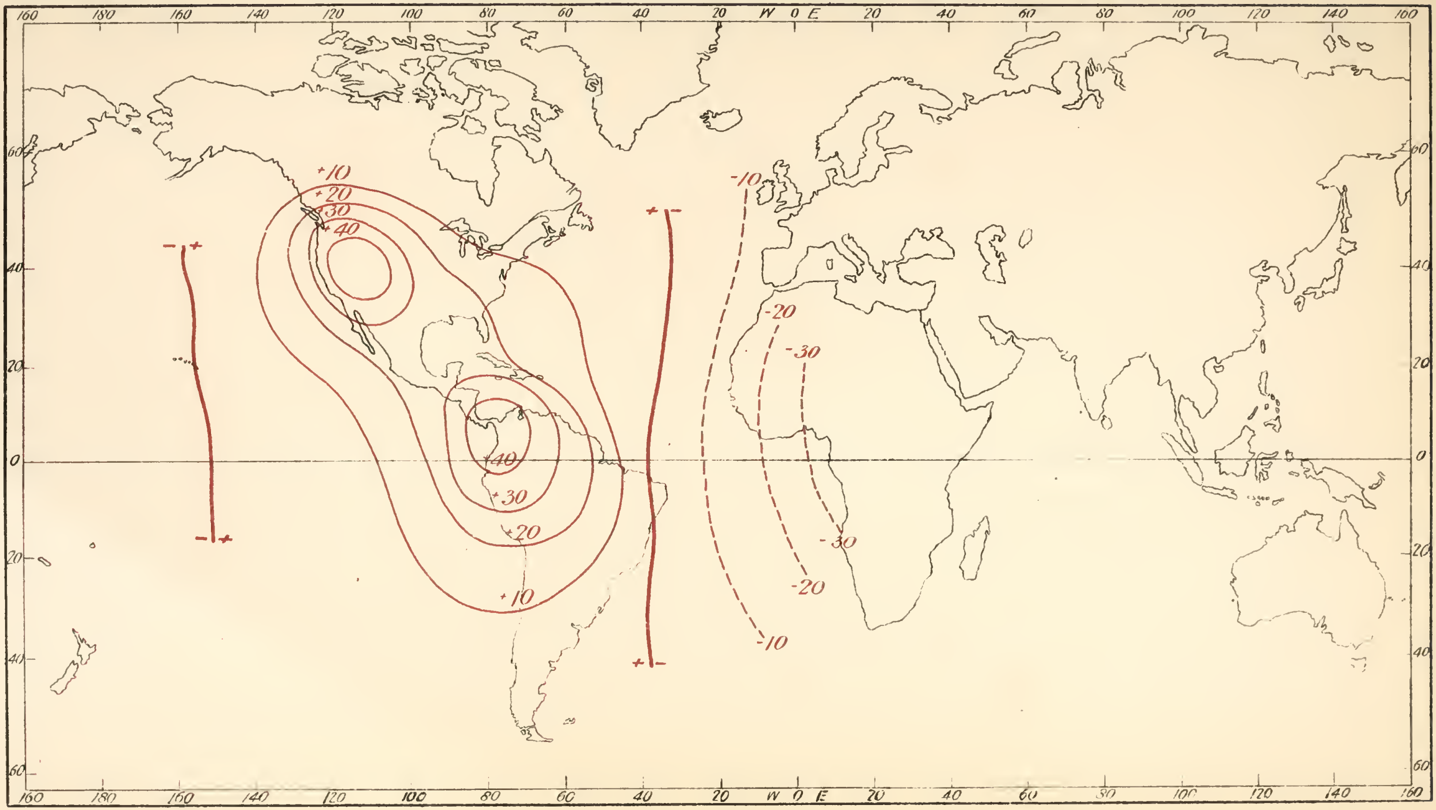


Plate XXI. Diurnal Westward Movement of Barometric Wave. 12 M. 12 Noon

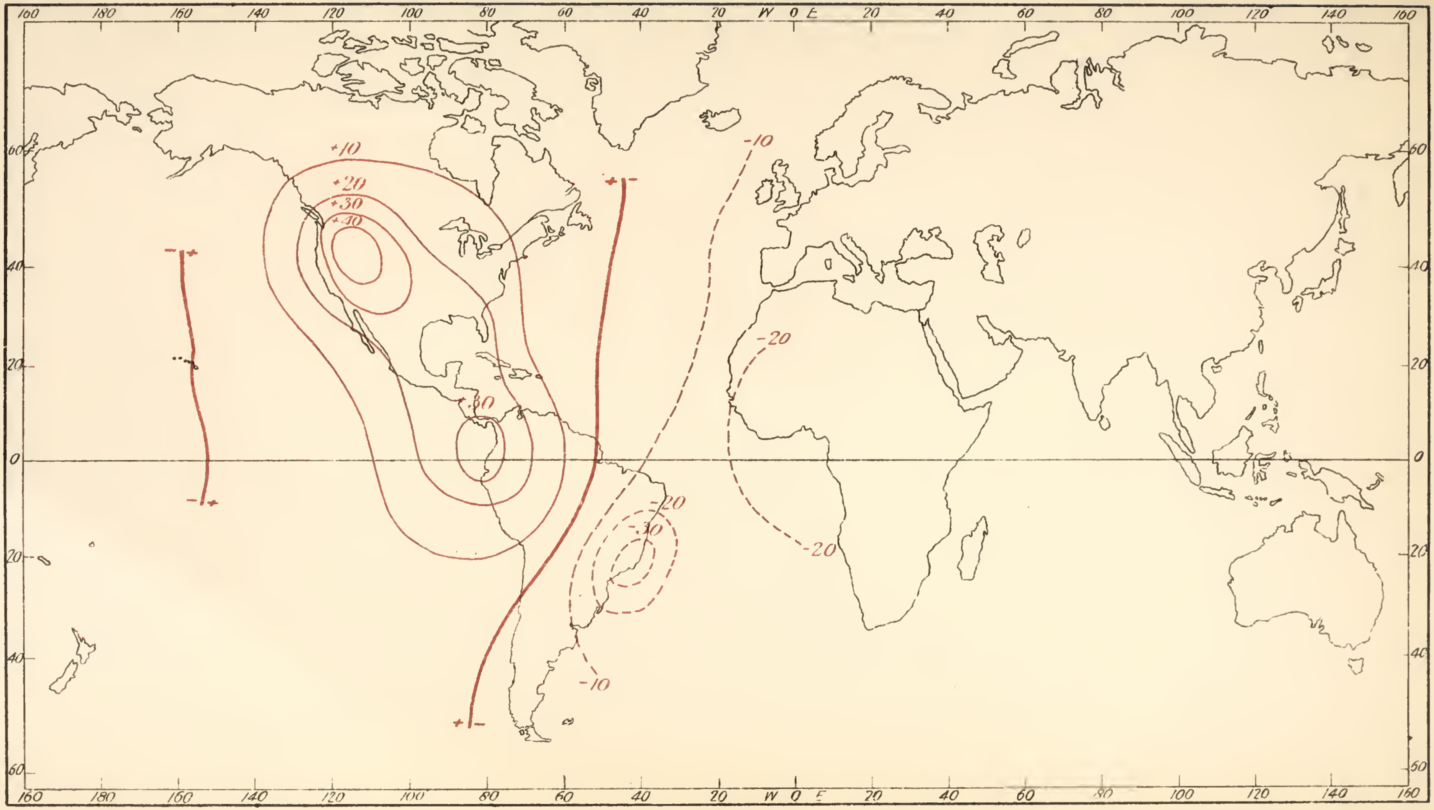
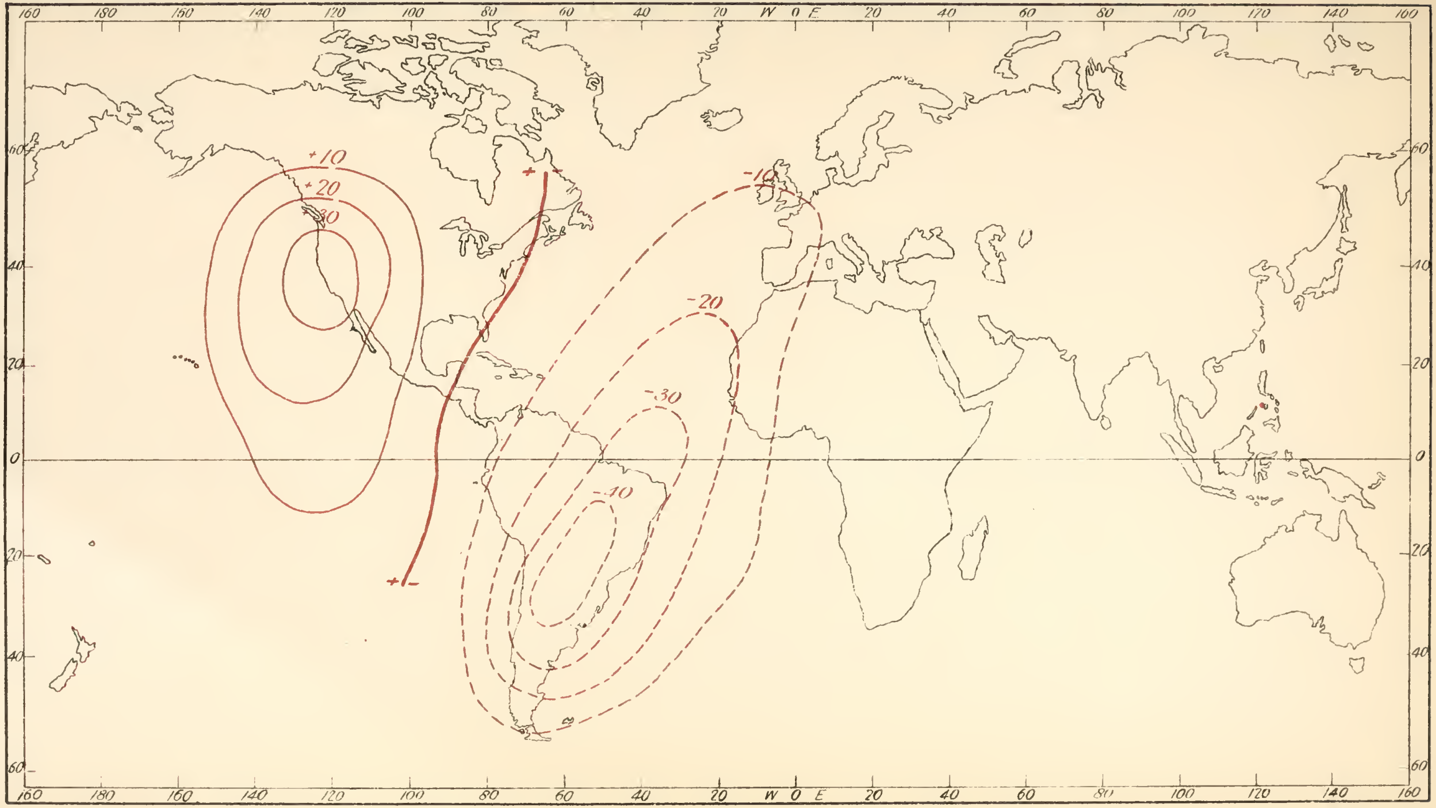


Plate XXII. Diurnal Westward Movement of Barometric Wave. 1 P. M.

1 P.M.



2 p.m.

Plate XXIII. Diurnal Westward Movement of Barometric Wave. 2 P. M.

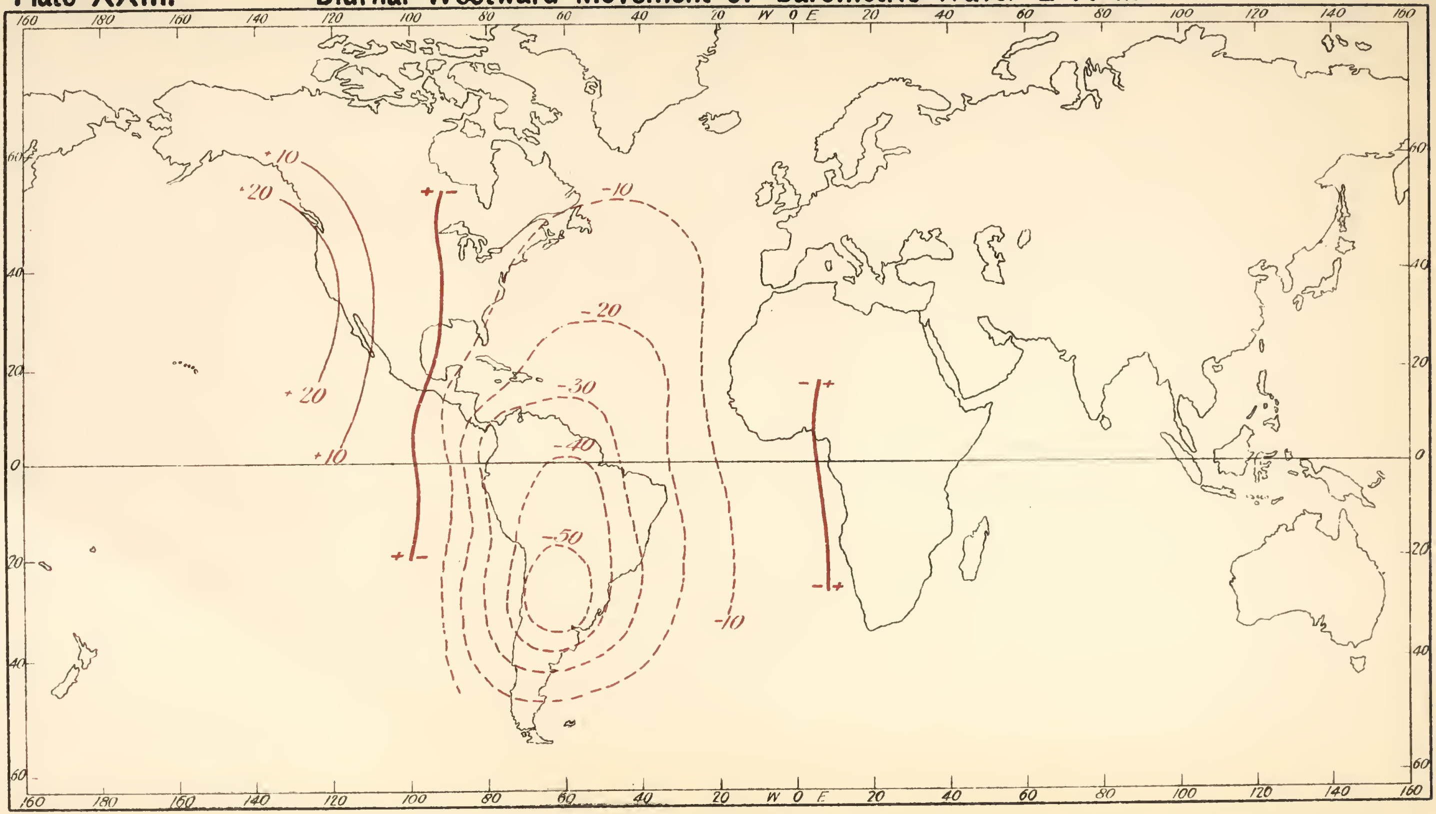


Plate XXIV. Diurnal Westward Movement of Barometric Wave. 3 P. M.

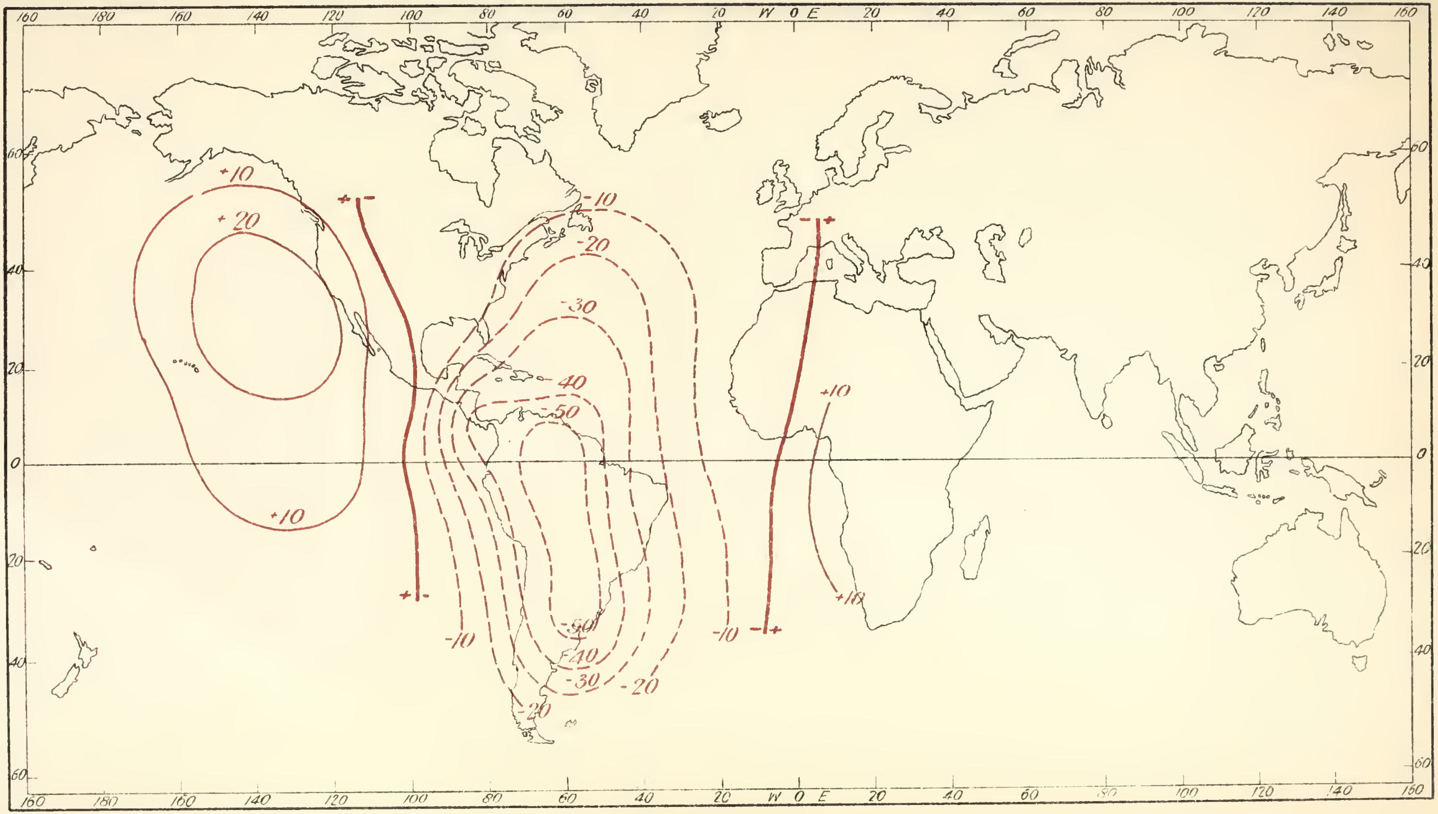


Plate XXV. Diurnal Westward Movement of Barometric Wave. 4 P. M.

4 - p.m.

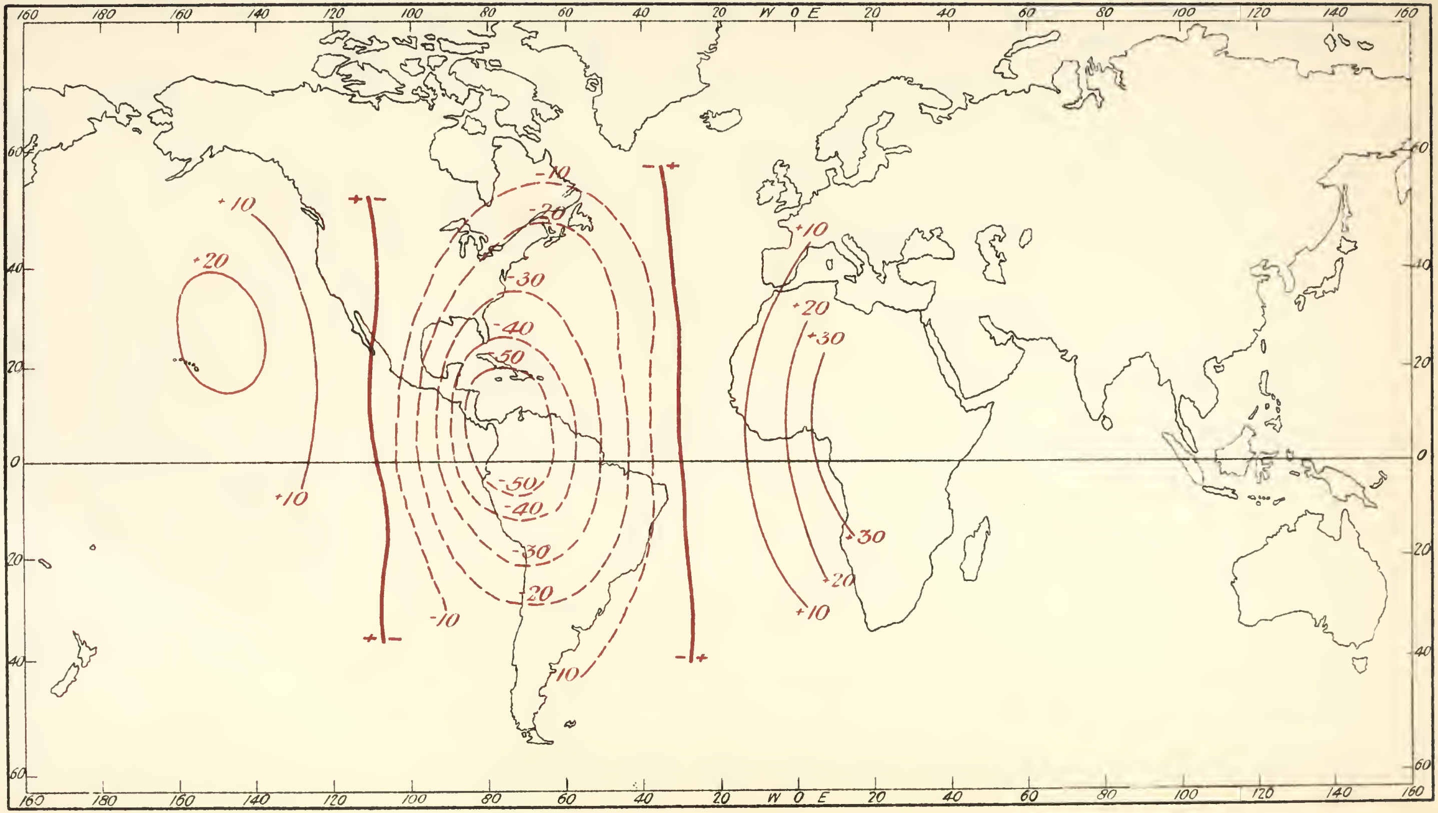


Plate XXVI. Diurnal Westward Movement of Barometric Wave. 5 P. M.

5 p.m

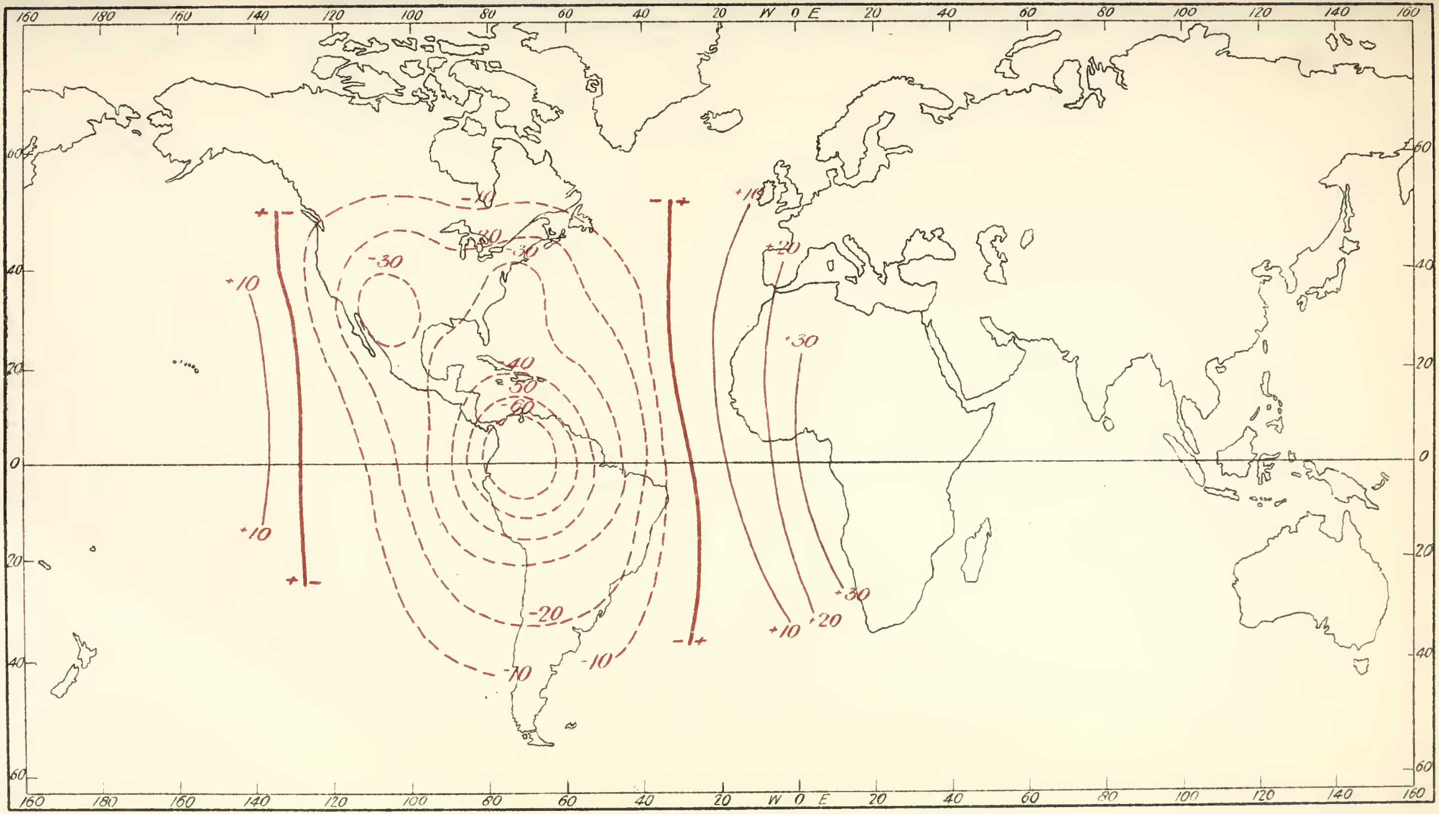
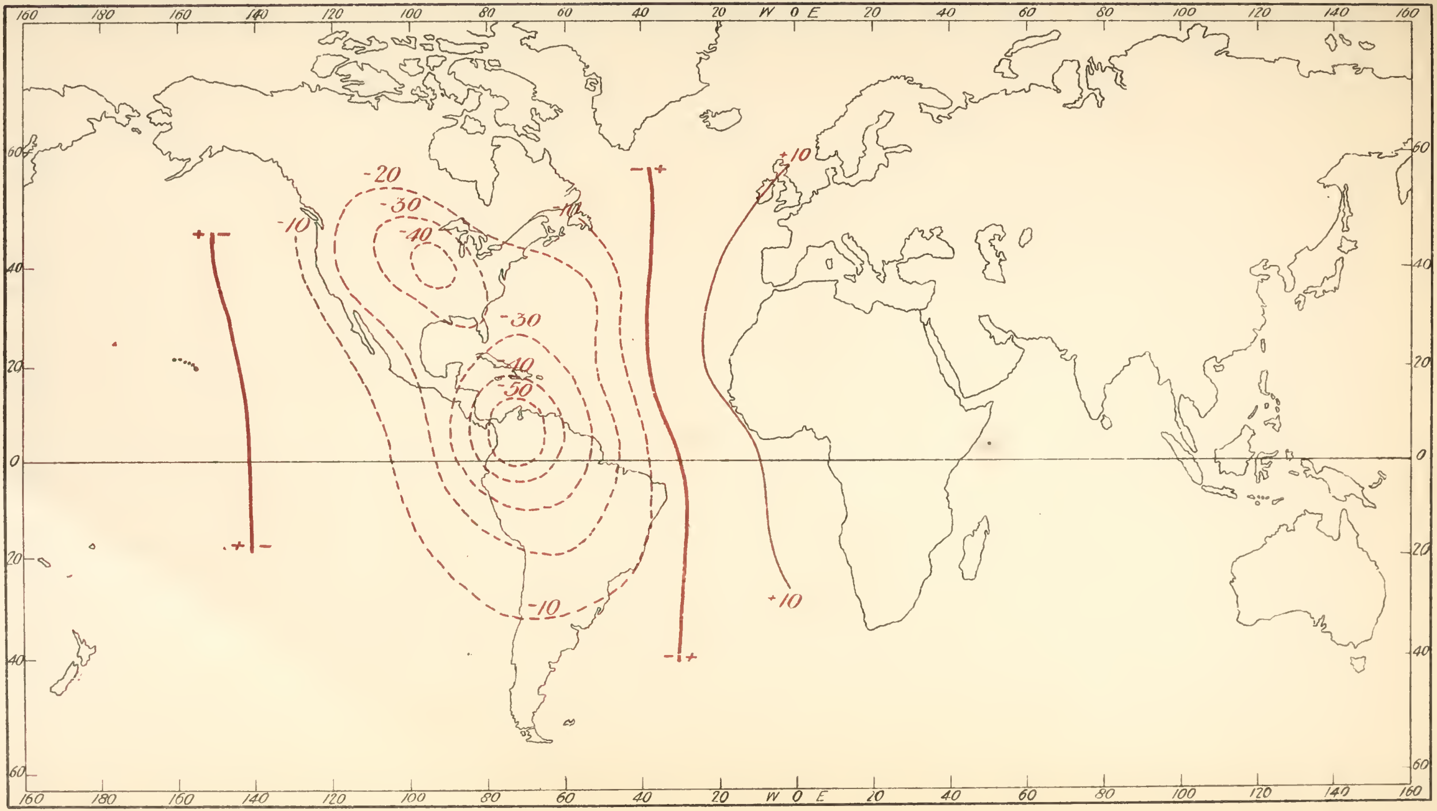


Plate XXVII. Diurnal Westward Movement of Barometric Wave. 6 P. M. 6 p.m.



7 p.m.

Plate XXVIII. Diurnal Westward Movement of Barometric Wave. 7 P. M.

Plate XXIX. Diurnal Westward Movement of Barometric Wave. 8 P. M. 8 p.m

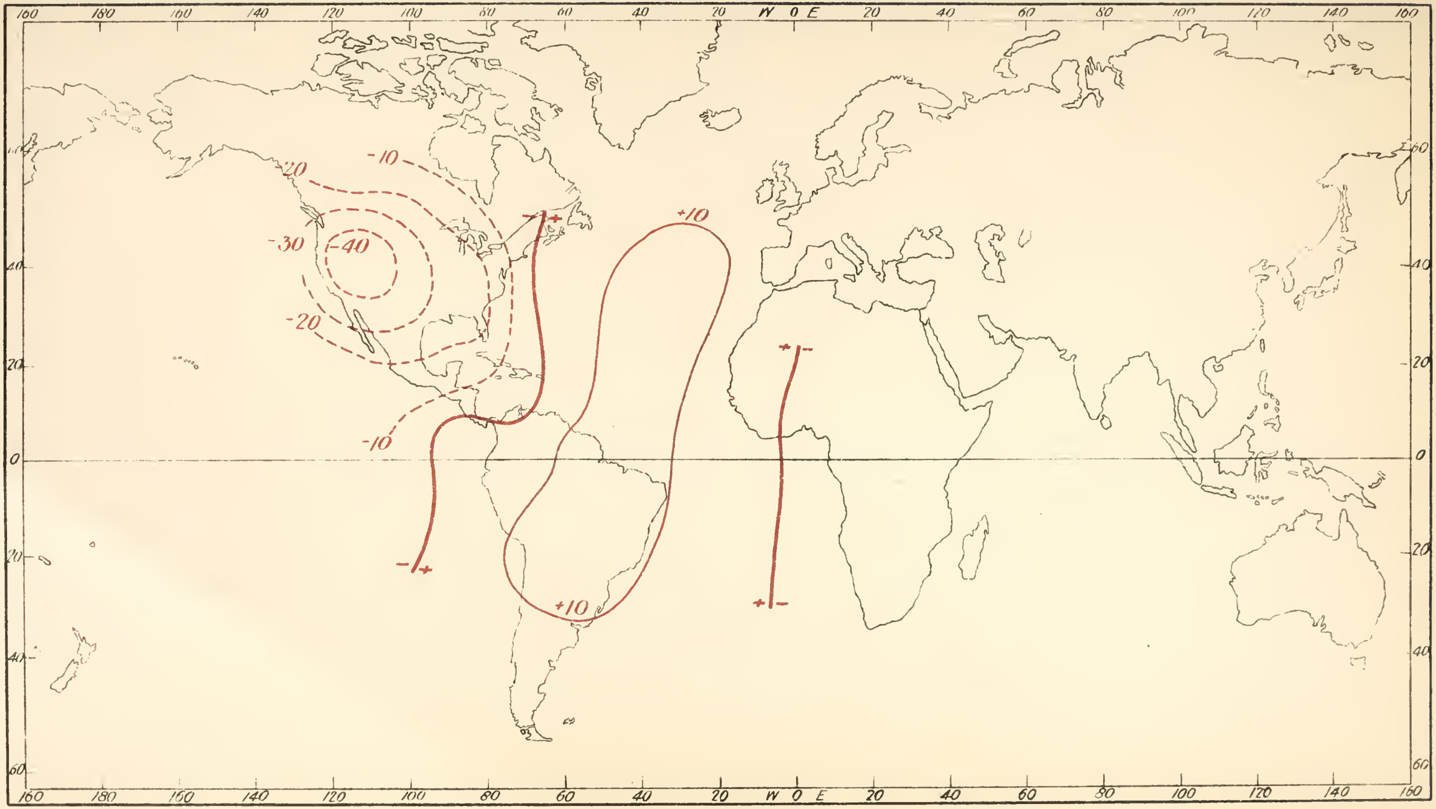


Plate XXX. Diurnal Westward Movement of Barometric Wave. 9 P. M. 9 p.m

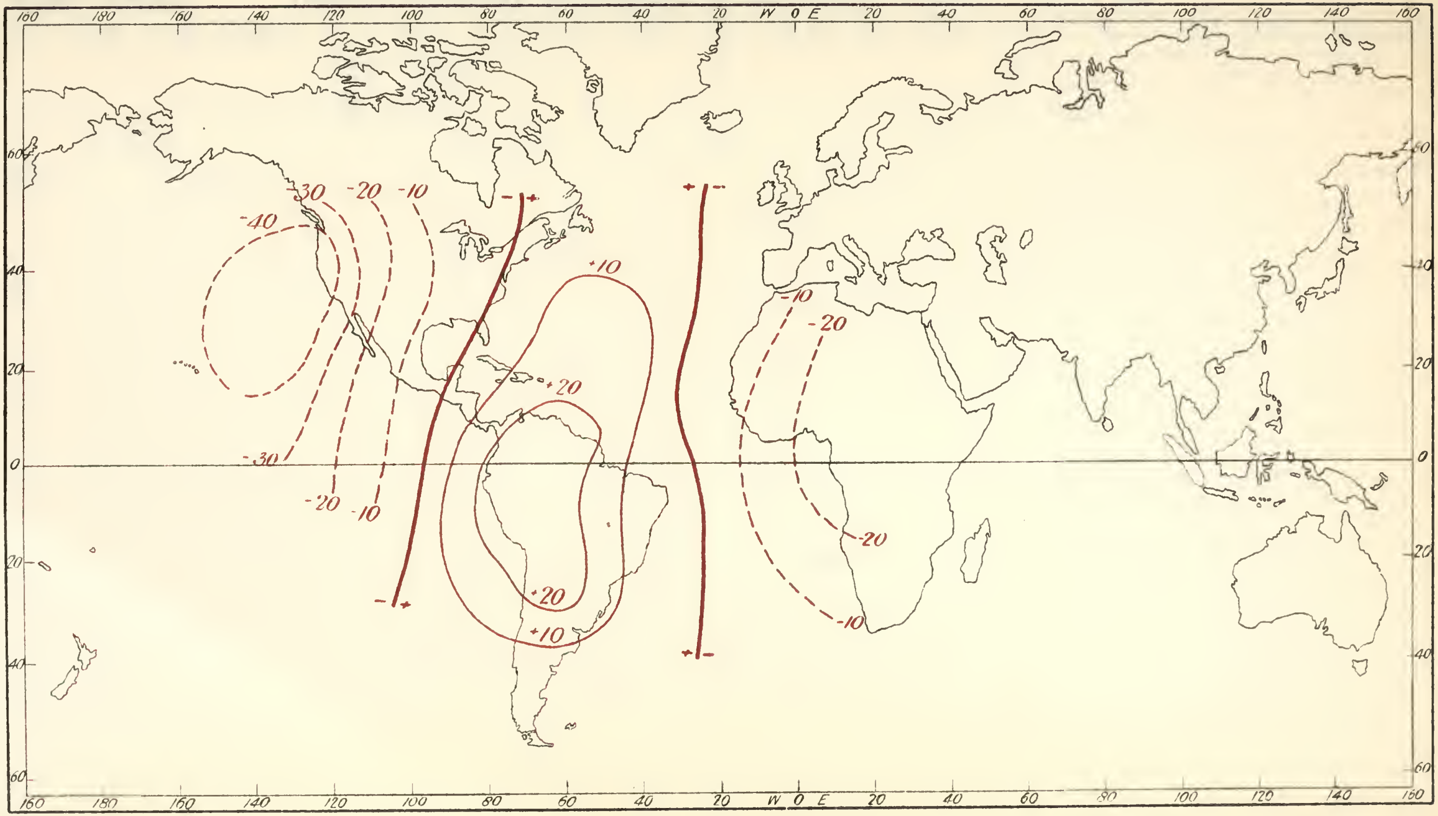


Plate XXXI. Diurnal Westward Movement of Barometric Wave. 10 P. M.

10 - p.m.

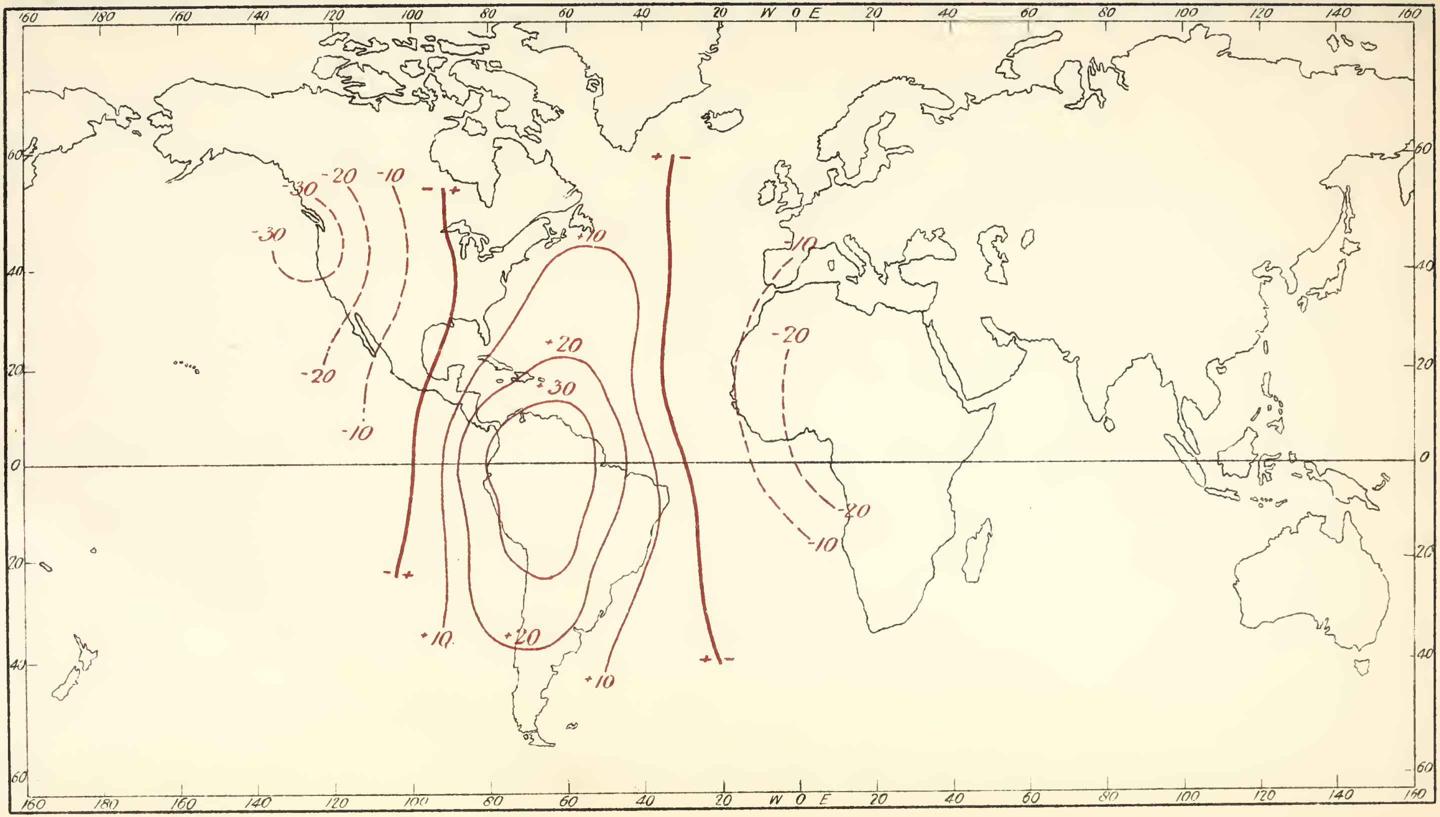


Plate XXXII. Diurnal Westward Movement of Barometric Wave. 11 P. M.

11 p.m.

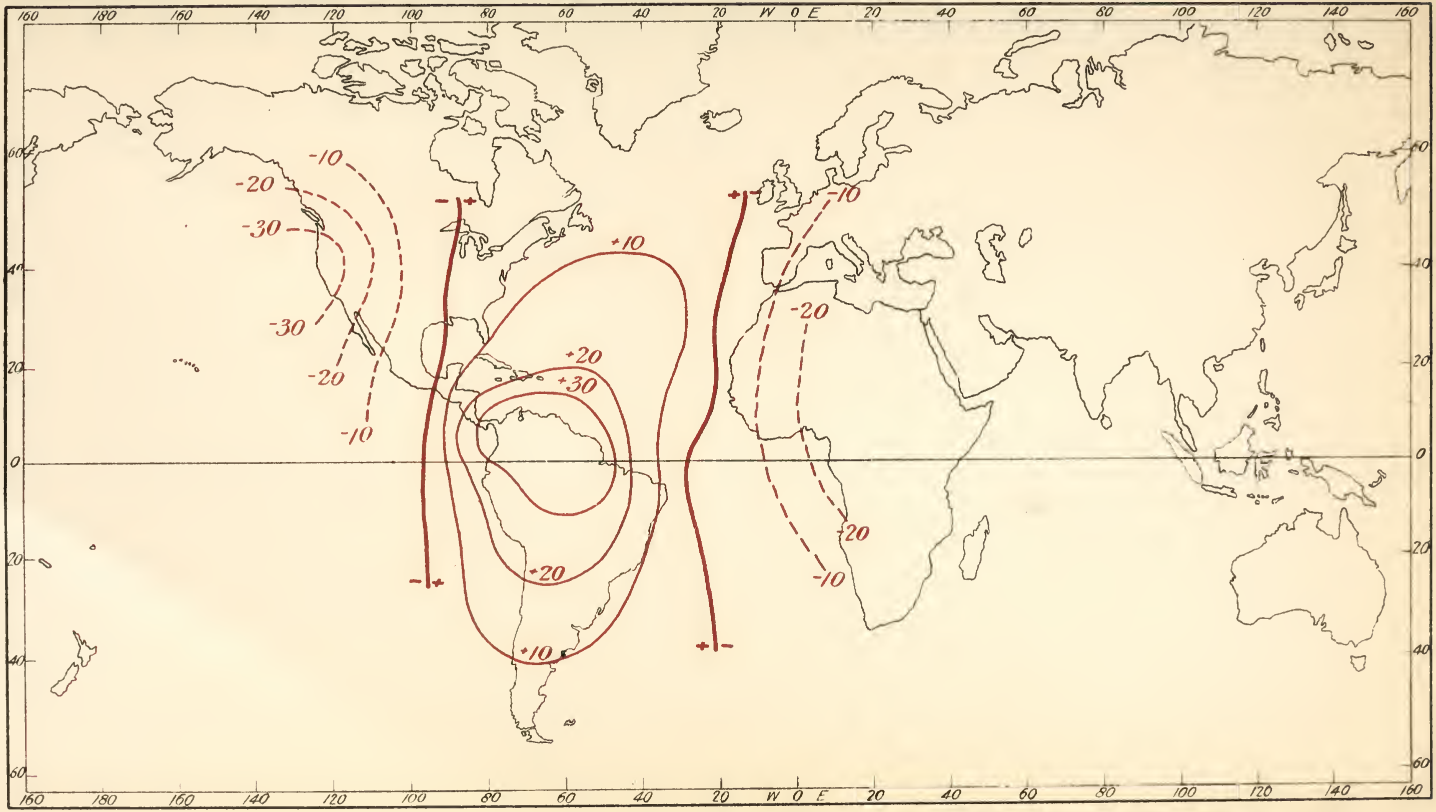
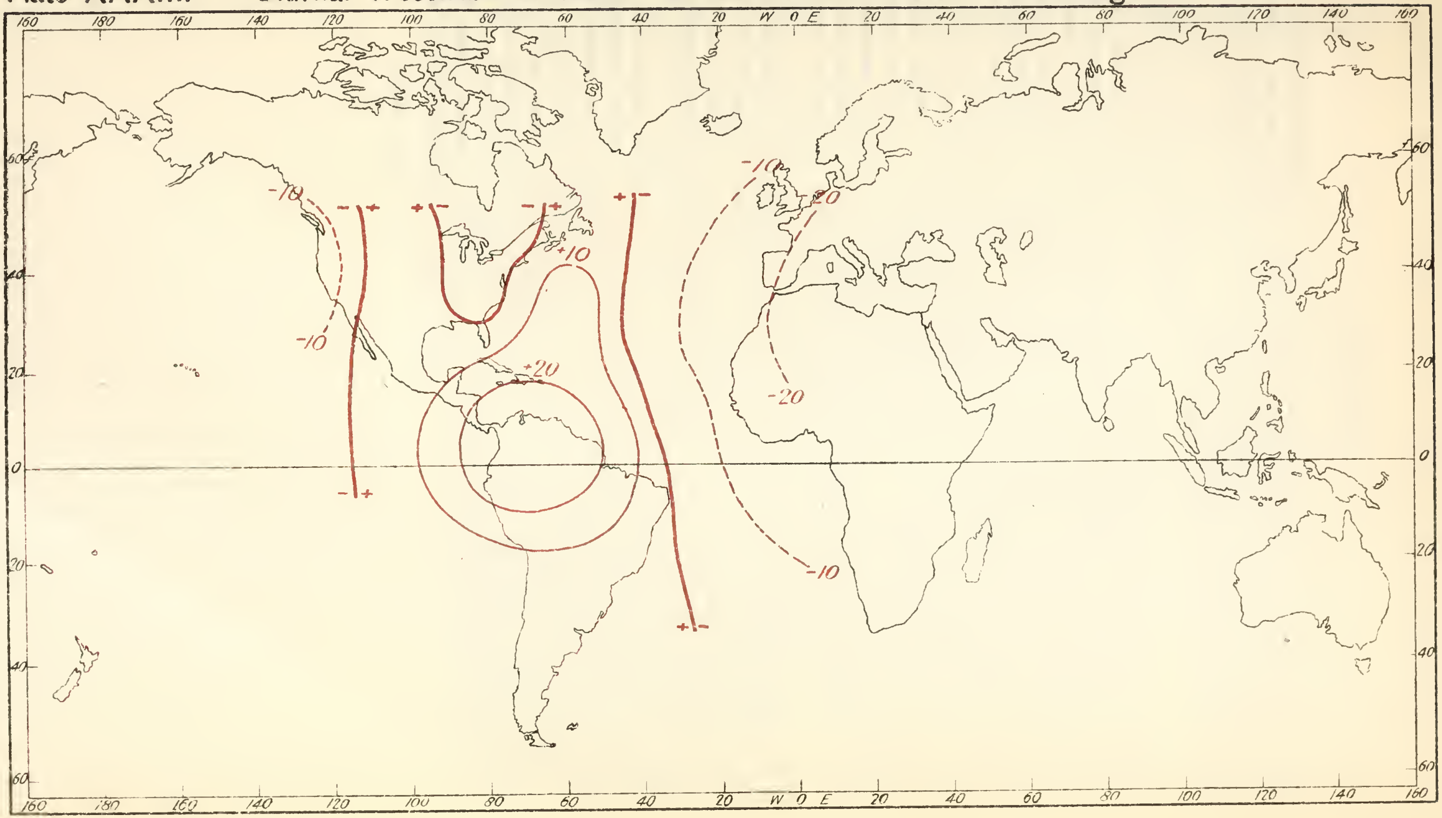


Plate XXXIII. Diurnal Westward Movement of Barometric Wave. 12 Midnight.

12 Midt



DISCUSSION.

Professor MOORE. This movement is beautifully portrayed by the charts accompanying this paper. Starting at 1 a. m. on the west coast of Europe, at 2 a. m. the barometric wave is in the center of the Atlantic Ocean, and by 6 o'clock it is passing off our western coast into the Pacific Ocean. I think this paper is quite unique and is entitled to great consideration.

Professor BIGELOW. The movement of the diurnal wave is perpetual; still one can observe it at a given locality in successive hours. Of course the true understanding is to be had by platting it on a sphere, instead of taking a small number of hours in succession in the same longitude as the American continents. I think that the movement westward consists merely in the fact that the earth turns eastward, as under a collar. The interesting thing in this paper, which I believe scientists will appreciate, is this: The swing of the axis of the wave is over the continent under certain conditions and over the ocean under others. That points distinctly to the explanation that the effect must be due to a rotation phenomenon. The change of pressure increases under certain conditions at the continents and under others at the oceans. On the whole, I should suppose that the phenomenon is one of rotation and not a movement of the air as such.

Mr. CLAYTON. I wish to call attention to one of the most interesting aspects of this phenomenon to me; that is the extreme rapidity of the movement, whether we consider the earth as moving under the wave or the wave as moving over the earth. It is moving a thousand miles an hour in the equatorial region. Our ordinary storms move only 30 to 40 miles an hour, but this little diurnal cyclone is moving a thousand miles an hour in the opposite direction to that of the ordinary storm. It has very much the same shape as the ordinary cyclones and anticyclones we have on the map, only it moves with a velocity many times as great. I wish you would call attention at your stations to the watching of the daily changes of the wind as these barometric waves swing by. At Blue Hill the daily shifting of the wind is very distinct. In the big cyclonic movements, of course, all these waves are hidden, but the time to observe them is when we have what is called a "flat" map.

A METHOD FOR THE SYSTEMATIC EXPLORATION OF THE ATMOSPHERE BY MEANS OF KITES.

By Mr. A. LAWRENCE ROTCH, *Director of Blue Hill Meteorological Observatory.*

Although the exploration of the air by means of self-recording instruments, lifted by kites, has been in progress at my observatory since 1894, and several hundred flights have been made in almost all weather conditions up to an extreme height of 3 miles; yet, since a wind of at least 12 miles an hour is required to raise the kites, there are certain types of weather, such as anticyclones accompanied by light winds, that can only be studied high above the earth by means of kites when these are sent up in advance of the anticyclone and allowed to descend in the area of high pressure. In 1898 the United States Weather Bureau equipped 17 stations with kites in order to obtain daily observations at the height of a mile for forecasting the weather. The experiment failed because the light winds during the summer prevented flights from being made regularly at all the stations. Nevertheless, information was obtained concerning the vertical gradients of temperature over a wide area in the central part of the United States.

The systematic exploration of the atmosphere above the Continent of Europe has been in progress for several years under the direction of an international committee, of which I am the American member. Ascents of manned balloons and balloons carrying recording instruments only to still greater heights are now made each month in several countries, and kites are used to supplement the observations at the highest altitudes. It frequently happens, however, that on the day of the balloon ascent the wind at the ground is insufficient to raise the kites. Since the balloons drift with the upper currents to considerable distances, the comparison of the data obtained from them with observations made at designated stations on the ground is more or less uncertain.

The method which I have the honor to propose obviates both these difficulties, the chief one being, of course, the necessity of having windy weather to fly the kites, and renders it possible to obtain at nearly all times information about the upper air and this in regions hitherto inaccessible. Briefly stated, it is the employment on steamships of kites carrying meteorographs, especially on vessels cruising in tropical oceans. Kites can be used on shipboard more frequently and to better advantage than on land, since they can almost always be flown from a stationary or a moving ship. For example, when the air is calm, by steaming through it at a speed of 10 or 12 knots the kites can be raised easily to the height that they would reach in the most favorable natural wind, and, on the contrary, the force of strong winds can be reduced if the vessel moves with the wind. Often, while there is sufficient wind near the surface, it fails entirely at the height of the cumulus clouds, and in this case it would only be necessary to put the ship in motion to carry the kites through the calm zone and into the upper current that may suffice to lift them.

To make these observations properly requires a vessel that can be started, stopped, and turned at the will of the meteorologist, who may thus explore the heights of the atmosphere, just as the hydrographer and zoologist have explored the depths of the ocean. Had the *Challenger* on her cruise around the world been provided with our modern kite apparatus and accompanied by meteorologists trained in its use, it might have accomplished the double task of sounding the oceans of

air and water. The German antarctic vessel *Gauss* is equipped with meteorological kites, which will be used on the southern voyage just begun, but it is to be feared that this branch of the meteorological work, being subordinate to the main aims of the expedition, will always be sacrificed to them. Dr. Gregory, who was to have been the scientific head of the English antarctic expedition that has recently sailed on the *Discovery*, intended to employ kites at the polar station, and last year visited Blue Hill to examine our installation.

The storage and handling of kites on steamships seem to present no serious difficulty, for power is available at all times to operate the kite winch and the wire from it may be led over a pulley on a yardarm, capable of being turned so as to bring the kites clear of the rigging, etc. The launching of a kite from a ship would be easier than on land, owing to the greater steadiness of the winds at sea. Wherever the observations in the upper air may be made, there is always the observing station on the ship not far distant horizontally with which to compare them. Although observations above all the oceans are valuable, the equatorial region is the most important to be explored, for, with the exception of a few observations on the Andes and on mountains in central Africa, we know nothing of the thermal conditions prevailing a mile or two above the equator. The importance of such data to complete our knowledge of the thermodynamics of the atmosphere was stated by the Russian meteorologist Woeikof at the meteorological congress at Paris last year. Within the trade-wind belts, north and south of the equator, kites might be employed to determine the height to which the trades extend and also the strength and direction of the upper winds, concerning which the high clouds that are rarely seen in those latitudes give us what little information we now possess.

The atmosphere above the equatorial oceans can be best explored by a vessel having a speed of not less than 12 knots and possessing sufficient deck room to permit of handling the kites. A boat suitable for the purpose is the *Princess Alice*, the exploring yacht of the Prince of Monaco, who has manifested interest in my project. Meanwhile the German meteorologist Köppen is proposing to make observations with kites from a sailing vessel bound across the equator, but it is evident that the main advantage mentioned would be lost on a vessel driven by the wind. In any case it must be remembered that scientific kite flying requires practical and skillful operators, and without them and much reserve apparatus will yield mediocre results.

This use of kites on a vessel that could be maneuvered at will was demonstrated by me on a towboat in Massachusetts Bay on August 22, 1901. Anticyclonic weather conditions prevailed, and the velocity of the southeast wind at sea level varied between 6 and 10 miles an hour, but at no time was sufficient to raise the kites either there or at the Blue Hill Observatory. The maximum speed of the towboat was 10 miles an hour, but by altering the course of the boat with respect to the wind, an artificial wind of 0 to 18 miles an hour was created, the angle through which the boat could be turned and still provide sufficient wind for the kites being about 90°. The uniformity of the artificial wind facilitated launching the kites, which rose with great steadiness at a high angle, carrying the meteorograph to an elevation of half a mile. I shall next endeavor to obtain meteorological data with kites on a steamer crossing the North Atlantic.

(The eminently satisfactory results of this voyage are described in "Science" of December 6, 1901, and reprinted in the Monthly Weather Review for December, 1901.)

A MARKED RISE IN THE NORMAL BALTIMORE TEMPERATURE CURVE FOR MAY.

By Mr. Oliver L. Fassig, Ph. D., *Baltimore, Md.*

[Read by title.]

In European literature on meteorology, we meet with frequent reference to certain periods of regression of temperature in spring and early summer, periods during which the steady seasonal advance is checked by a reversion lasting three or four days. One of these periods has received the attention of many writers during the past twenty or more years, namely, the three days from the 11th to the 13th of May. There are other similar days, but these, occurring at a critical period in the growth of vegetation, are more feared by the husbandman in Central Europe than those occurring earlier or later when the dangers of frost are less. The three days most liable to frost, in the estimation of the people, are usually referred to as "The three frost saints," or by some similar popular phrase.[a]

The phenomenon has received the attention of the foremost European meteorologists, and is based upon something more than a popular belief in the occurrence of injurious frosts at this time. The explanation is found in the usual development at this time of a barometric depression over southeastern Europe, in conjunction with the appearance of an area of high pressure over the North Sea, this distribution of pressure causing north to northeast winds and clear nights, with rapid nocturnal radiation, over Central Europe.

Within the past month the writer has constructed a normal curve of temperature for Baltimore, based upon the daily mean for the past thirty years (1871–1900). Upon completion of this curve, the portion representing the month of May was the first to be examined, with the hope of finding in it some trace of a departure similar to that so familiar to European meteorologists. The expected fall in temperature is not to be found in the Baltimore curve; in its place, on the contrary, there is a sharp, well-defined rise from the 9th to the 12th, amounting to 3 or 4 degrees above the average of the 8th and 13th, as illustrated in fig. 4.

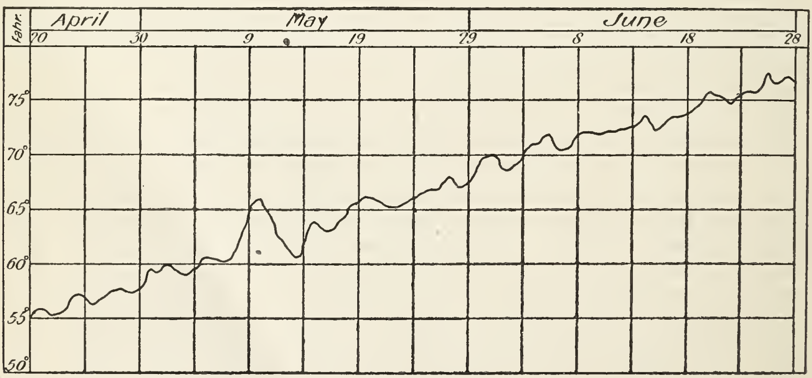


Fig. 4.

A temperature departure which persists to such an extent in a curve smoothed by thirty years of accurate daily observations is a signifi-

[a] "Kälterückfulle in Mai."

cant feature of the local climate. The writer has had no opportunity as yet to investigate the geographical extent of this departure, or the peculiar distribution of atmospheric pressure to which it is probably due, but it will doubtless be found to extend over a large area, and to be associated with the appearance of the summer type of pressure distribution, namely, the development of a high area over the South Atlantic States, or rather the westward extension of permanent area of high pressure over the North Atlantic, giving rise to a short period of light southwesterly winds and clear skies. This type does not recur regularly on the same days of the month, but the sharp rise in the normal curve from the 9th to the 12th shows a decided tendency to appear at this time.

THE ADVENT OF SPRING.

By Mr. CHARLES F. VON HERRMANN, *Raleigh, N. C.*

[Read by title.]

Our genial poet and philosopher, Oliver Wendell Holmes, has divided the lookers on at the grand show of Nature—the progress of the seasons—into three classes—the poets, who perceive the beauty of things; the naturalists, who collect curious facts in regard to the habits of birds, insects, and flowers, and the scientists, with their infinitely unreadable tables of statistics relating to temperature, storms, and other objects of study. To these I venture to add another class—the people who are interested in the utilities of nature. To all engaged in agricultural pursuits the changes of the seasons are of so much practical importance as to require to be viewed from a more serious standpoint, and perhaps the patient labor of a scientific investigation will yield more of real value than the curiosity of the naturalist or the inspiration of the poet.

The advent of spring is the result of a very complicated series of changes, depending primarily upon the position of the earth in its orbit, which is made manifest to us by the retrogression of winter, the increased temperature of the atmosphere and soil, the awakening of plant life, and the various movements of animals which are induced by migratory instincts. The sum total of impression received at this attractive period of the year is the effect of the concurrence of many events between which we seek to trace some correlation or to untangle the threads of natural law which gives unity to all the phenomena of nature. The endeavor to fix a date for an event so variable as the advent of spring presents great difficulties. The civil division of the year, in which spring comprises the months of March, April, and May, suggests that astronomically the date of the vernal equinox, March 21, may be considered the beginning of spring for the northern hemisphere. From the present point of view, however, this date, applying to the northern hemisphere as a whole, has no significance in the tropics or the polar regions, neither of which can be said strictly to have a spring. While the event is a general climatic one, it is also local in character, and is modified for any place by its latitude and geographical position, by altitude or proximity to the sea, and by many minor features of topography. Spring arrives earlier in a sheltered valley or on a southern declivity than on a bleak hillside

exposed to the north wind. The successive movements of cold waves of ever diminishing force also show that the advance of spring is not like the steady progress of the crest of a flood wave, but fluctuates—now advancing, now retreating, always slowly gaining, so that summer becomes dominant almost imperceptibly.

Of the manifold changes following the retreat of somber winter, which shall be used as the criterion for the advent of spring? Many events have been proposed for this purpose, as the breaking up of ice in rivers and the reopening of navigation, the movements of animals, the earlier phases of the growth of vegetation, and those employed by the meteorologist, as the advance of an adopted isotherm of mean temperature, or others depending on some supposed relation between climate and the other phenomena mentioned. It may be interesting to discuss each of these briefly.

The first named—the breaking up of ice and resumption of navigation—will necessarily find only limited application in northern regions, where the rivers remain frozen throughout the winter. Anyone interested in studying the average dates of the reopening of navigation in the northern rivers and the Great Lakes will find ample material in the Monthly Weather Reviews. At many places the arrival of the first boat is an event of much importance. The average date for the reopening of the Hudson river at Albany is March 19, from records extending back to 1786. The average date for the opening of the Kennebec at Augusta, Me., is April 6. A general examination of data of this kind, however, will show that the dates so found are too early to represent the advent of spring. As our object is to secure data for a sufficiently large number of stations throughout the United States to enable the construction of a chart graphically illustrating the successive advance of spring, the use of this criterion is impossible for lack of material in the warmer regions of the South, where the rivers never freeze.

The movements of migratory birds or of hibernating animals afford a very unsatisfactory means of determining the approach of spring. A sufficiently large number of trustworthy observations is not available, and most of the movements recorded are not made for the reasons usually assumed. It is a common error to suppose that animals, by some unknown sense, are able to foresee weather changes, and this vitiates the scientific value of most of the observations recorded. Very often these migrations are simply brought about by the exhaustion of the food supply in a certain region. It is true that many animals possess a superior sense of smell, of sight, or of hearing, perhaps a finer sensitiveness to minute atmospheric disturbances, which man has lost by his artificial mode of life (the use of fire, clothing, and shelter) removing him, in a measure, from the direct influence of nature; but for this loss he is fully compensated by his ability to invent and use the delicate instruments of modern scientific research. The special faculty, seemingly possessed by many animals, of anticipating the seasons is not due to a superior knowledge of meteorology, but is the result of experience during past ages, transmitted from one generation to another by inheritance, and producing the fixed habits of life now observed.[a] Many curious observations in regard to the first appearance of the ground squirrel, the migration of swallows, the far-off song of wild geese hurrying northward, may be found in that old

[a] American Meteorological Journal, May, 1887, Popular Errors in Meteorology, by Prof. Cleveland Abbe.

classic, White's Natural History of Selborne, which contains also a model naturalist's calendar for that locality.

From the point of view of the naturalist, the ideal criterion of the advance of spring must be the awakening of plant life. Plants are fixed in their habitat, and are subjected to all the influences of their environment, and while the progress of growth is largely controlled by chemical and physical features of the soil, the chief factors must be temperature, moisture, and sunshine. Plants reflect perfectly the successive phases of the grand panorama of the seasons from the moment when the first warm breath persuades the crocus to push up its flowers through the snow. The determination of the commencement of the various phenoma of plant life, of the unfolding of the foliage and flower, the ripening of the fruit, and fall of the leaf, in their relation to the seasonal changes that take place, constitute the so-called phenological observations. Phenology is extremely important in the study of the geography of plants, and is of no less value for climatology, though meteorologists have rather neglected this attractive work. The large mass of material available must generally be sought in botanical works, and it is to be regretted that the memoir on the subject of phenology prepared by Prof. Cleveland Abbe in 1891 was not published by the Weather Bureau.

The difference in the behavior of different species of plants serves to give account of the gradual advance of spring. Thus the snowdrop, bloodroot, and claytonia herald the earliest touch of spring; peaches and cherries bloom early, and often suffer for their intrepidity; while oaks and walnuts are slow to respond to the influence of warm weather.[b] There are two ways of utilizing the material furnished by phenological observations. By comparing the dates of blossoming of the same species of plant at different places, the retardation of vegetative development with increasing latitude is brought out, with such variations as may be caused by topographical features. Using the island of Lesina in the Adriatic Sea (latitude 43° N.) as the starting point, it has been found that spring at Paris (latitude 48°) is retarded forty-three days, at Brussels (latitude 50°) fifty days, and at Christiania (latitude 60°) eighty-six days. In continental Russia the retardation is much greater, and while at Paris many spring plants are in full bloom vegetation on the Russian steppes, at the same latitude, is still deep in winter sleep.[c] Again, we may ascertain the places where spring plants blossom simultaneously, and a comparison of the latitudes will reveal the influence of climate. Thus, at New York, which is at the same latitude as Naples, plants blossom at the same time as at Marburg, Germany, 10° latitude farther north.[d]

The first attempt in this country to compare the seasons by the flowering of plants was made by Dr. Jacob Bigelow in a paper published in the Transactions of the American Academy in 1841.[e] The progress of the waves of warm air, as indicated by the flowering of the peach, was recorded for 1817 at the following places: Charleston, March 6 to 12; Richmond, March 23 to April 6; Baltimore, April 9; Philadelphia, April 15; New York, April 21 to 26; Boston, May 9; Albany, May 12, and Montreal May 12.

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[b] The Advent of Spring, M. W. Harrington, Harper's Magazine, May, 1894.
[c] Natural History of Plants, Kerner von Marilaun, vol. 1, p. 565.
[d] Ibid. p. 566.
[e] Works of Oliver Wendell Holmes, Riverside Edition, vol. VIII, p. 132.

Comprehensive statistics of this kind are available and would repay detailed investigation. I think, however, in phenological observations too exclusive attention is given to the effect of temperature on growth. The condition of the soil, which is the seat of complicated physical and chemical changes, is of the highest importance to the growth of vegetation, and it may be that frequently the permanent warmth of the soil has more to do with starting the flow of sap in spring than the temperature of the air, since in countries without a winter covering of snow the temperature of the soil is higher than that of the air above it throughout the year. The influence of moisture is also largely neglected. In tropical countries many plants undergo a period of rest during the dry season, which corresponds with our winter, and an increase in the amount of moisture at the beginning of the rainy season calls forth all the phenomena of a luxuriant spring. In addition, while many plants possess elaborate means of protection from excessive loss of moisture by transpiration, it is still doubtful whether any means of protection from changes of temperature have been discovered. A botanist can tell at a glance whether a plant occupied an arid or a humid region, but he can not say that it belonged to the flora of a cold or warm climate.[a]

The determination of spring by the successive advance of an adopted isothermal line is the method which naturally commends itself to the meteorologist, and is the only one possible for the purpose of a graphic representation. The endeavor is made at the same time to select an isotherm which has some distinct relation to the phenomena of plant growth. The only attempt of this kind with which I am acquainted was made by Prof. Mark W. Harrington, in Harper's Magazine for May, 1894. Professor Harrington accepted as the criterion the advance of an isothermal line of 43.8° F., and endeavored to establish a causal relation between the adopted temperature and the beginning of development in plants, in the following words:

> Botanists state that the temperature of 42.8° F. is that at which the protoplasmic contents of the vegetable cell find the limit of their activity. When the temperature falls below that point the protoplasm becomes inactive, though it is not dead until the fall is from several to many degrees lower, depending on the species of plant. When the temperature rises and reaches that point the protoplasm awakens, and as it passes above 42.8° F. the cells begin to grow and multiply. The advent of spring may be considered to take place at the advent of an isotherm 1° higher, or at 43.8° F.

This statement seems to me to be open to serious criticism, and the isothermal line adopted is really quite arbitrary and with very little relation to the phenomena it is supposed to mark. It can only be conceded that the rapid and agreeable change from the dull gray of the forests to a refreshing green does not occur much below that temperature, but otherwise it corresponds with no particular stage of vegetative growth.

Different stages of physiological activity in the protoplasm of plants probably occur from the lowest temperatures known up to several degrees above the boiling point of water. We consider here only the temperature minimum. Recent experiments by Dewar with liquid hydrogen, while not bearing strictly on this subject, may be mentioned for their intrinsic interest and the wonderful light they shed upon the problem of the origin of life upon the globe. The action of liquid hydrogen on certain bacteria was tested at a temperature of about

[a] Pflanzen-Geographie, Dr. A. F. W. Schimper, 1898, pp. 40, 41.

—418° F., or within 41° of absolute zero, for twenty hours without any impairment of the vitality of the organisms.[a] Perfectly dried seeds and the spores of certain algæ have about equally great powers of resistance to destruction by low temperatures. I venture to express the opinion that no degree of cold whatever is able to cause the death of perfectly dry, so-called resting protoplasm, yet it must be presumed that some faint trace of physiological activity continues even at these low temperatures. In growing vegetable cells the activity of the protoplasm is manifested between far narrower limits. Thus, in *nitella syncarpa* the streaming movements of the protoplasm, the direct indication of active life, continue at a temperature of 26° F. There is experimental proof that assimilation continues in the evergreen leaves of pines at temperatures near and slightly below 32° F. The growth of many plants is very active at temperatures near freezing. The development of the inflorescence of the snowdrop (*galanthus nivalis*) takes place easily and quickly at a temperature not much above 32° F. It has been proved with regard to the earliest phase of growth, the germination of seeds, which certainly involves a rapid multiplication of cellular tissue, that not a few species are able to germinate at very low temperatures. The seeds of white mustard, of wheat and rye, and of wild violets germinate between 32° and 34° F.; of flax, onion, poppy, and beets between 34° and 41° F.; beans and sunflowers, 41° to 51° F., and, on the other hand, cucumbers and melons do not germinate until the temperature rises above 61° F.[b]

It appears, therefore, impossible to select a temperature which shall represent a sharply defined stage in the growth of vegetation. The selection of the 44° F. isotherm is also inadmissible for a latitude where daily mean temperatures above that degree occur for days in succession, even in midwinter, and this compelled Professor Harrington to deny the Gulf States the pleasures of spring. Examining the criterion further by the results obtained, the criticism may justly be made that for a larger portion of the country the dates given are far too early. The earliest line shown on Harrington's chart is that for February 1, which passes through Norfolk, Va., over western North Carolina, above all the Gulf States to El Paso, Tex., thence northward above San Francisco. Over practically the entire region called the cotton belt spring is supposed to begin before February 1. For North Carolina this date is certainly very inaccurate. While the normal mean temperature for the State at large for February is 43.3° F., yet the month is frequently our most severe winter month, and it is the only one during half a century in which temperatures below zero have been recorded as far south and east as Raleigh. Spring can hardly be said to begin at Memphis, Tenn., on February 1. Professor Harrington's line for April 1 passes through Philadelphia, Indianapolis, slightly north of Denver, Salt Lake City, then curves northward to Spokane, and leaves the continent at Olympia.

A more practical criterion of the advent of spring is certainly to be found in the average date of the last killing frost or occurrence of a minimum temperature of 32°, an event which has been determined with considerable accuracy for a large number of stations throughout the United States. A killing frost is defined as one which will cause

[a] The Effect of Physical Agents on Bacterial Life, Dr. Allen Macfadyen, Popular Science Monthly, January, 1901.

[b] Natural History of Plants, Kerner.

the death of relatively hardy vegetation, including nearly all the plants of ordinary cultivation. It is well known that the young and tender vegetation of spring is easily destroyed by frost, and the important rôle played by the physical properties of water in the process are now well understood. Freezing depends on whether the affinity of the protoplasm for water is less than the molecular forces causing crystallization. If the affinity of the protoplasm for moisture is overcome, the water exudes from the cells into the intercellular spaces, where it crystallizes, and death results from the loss of water at a time when metabolic processes are at a minimum. From the point of view of agricultural interests the first and last killing frosts are events of much practical importance, which often exert a marked influence on the yield of crops. They determine, in fact, the limits of the growing period for most crops, and the immense damage often done by late frosts has led to strenuous efforts to secure means of protection. Consequently the last killing frost, as a natural event easily determined, with a distinctive influence on vegetation, may correctly be considered as marking the final passage of winter, the point of beginning of uninterrupted progress in the growth of vegetation—the advent of spring.

The records of killing frost at 130 stations of the Weather Bureau were used in preparing the charts accompanying this paper.[a] Many facts of great interest appear in this connection. The earliest date recorded is January 20, at San Diego; since, however, the people of southern California claim perpetual summer for that delightful climate, we can hardly permit them to enjoy the pleasures of spring. By February 1 spring has commenced along the entire coast line of the Gulf of Mexico and over Florida, but its progress during February and March is rather slow. The line for April 1 starts from a point on the Atlantic coast some distance north of Norfolk, Va., passes southwest through eastern North Carolina, curves around the south end of the Alleghenies, passes through Nashville, Tenn., above Cairo, Ill., and thence takes a wide southward bend below the Rocky mountain region; in the extreme West it passes directly northward along the western edge of the Sierra Nevada Mountains, and leaves the United States north of Seattle, Wash. Thus spring prevails over the entire Pacific coast region and throughout the cotton belt by the beginning of April. The advent of spring occurs during April throughout the larger portion of the United States, including the Middle and North Atlantic States, the Ohio and central Mississippi valleys, the eastern and southern slopes of the Rocky mountain region and sheltered valleys in the West, and is deferred to May only along the northern border from Northfield, Vt., through the upper lake region, and over the two most elevated regions of the West, the Rockies from Denver to Helena, and the Sierra Nevada of eastern California and Oregon.

The change from winter to spring is of course profoundly modified by the larger topographical features of the country, as well as by the influence of position in regard to the prevailing course of storms. There is a marked trend northward of the lines both on the Atlantic and the Pacific coasts, so much more pronounced on the latter that spring has already commenced at Portland, Oreg., and Tacoma, Wash., before it reaches Norfolk, 10° of latitude farther south.

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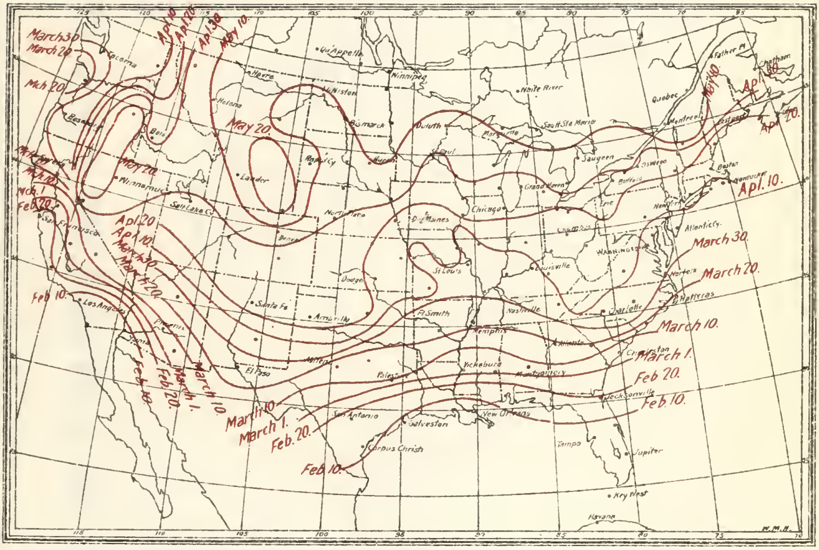
[a] Data furnished by the central office. See Plates XXXIV and XXXV.

Plate XXXIV. Average date of last killing frost in the United States.



There is also a moderate northward curve in the entire Mississippi valley as far north as St. Paul, and even a bend toward the northwest in the Lower Missouri basin. Spring occurs at Cairo before it begins at Charlotte, a hundred miles south, and at St. Paul before it reaches Detroit. This earlier advance of spring in the Mississippi Valley can hardly be attributed to the influence of the river itself, but must result from the fact that this section is open to the sweep of early southerly winds, caused by the successive development of areas of low pressure over the plateau region.

On the other hand, there are sharp southward bends of the lines of equal advent of spring over the Sierra Nevada and Rocky mountain regions, as well as over the lakes, the latter being farther extended southward by the influence of the Appalachian system. The retarding influence of the lakes is quite peculiar, as it falls chiefly on the eastern shores; in other words, spring advances in the lake region from west to east.[a] The retardation of spring in New England is partly to be attributed to the effect of elevation (White and Green mountains) but chiefly to the proximity of the frozen waters of the Gulf of St. Lawrence. Spring, however, is earlier on the coast of Maine than at any place in New York at the same latitude.

Attention may be invited to one more feature of special interest—the remarkable contrast in climatic conditions regarding the vernal season to be found in California and Oregon. The rapid advance of spring on the immediate coast from Los Angeles, February 6, to Seattle, March 31, has been referred to. Within little more than 100 miles in the vicinity of San Francisco, across the crest of the Sierra Nevada, is found the region of latest approach of spring in the United States. This comprises a portion of eastern California, western Nevada, and central Oregon, or the region between Carson City, Nev., and Baker City, Oreg., where spring is delayed beyond the middle of May, judging by the criterion here assumed. Over a considerable area of the extreme northwest, extending from Denver through Cheyenne and Lander, Wyo., to Helena, spring does not fully take possession until the middle of May.

From the nature of the case an investigation of the problem over more limited areas will yield details of greater interest. A similar chart has been prepared for North Carolina from the records of killing frost at 50 stations. The State is extremely diversified in topographical features; in its western region, poetically termed the "land of the sky," are found the highest mountains east of the Rockies, and its eastern extremity is thrust into the Atlantic beyond the normal trend of the coast line. On Smiths Island, near the mouth of the Cape Fear river, vegetation of semitropical nature flourishes. The time required for spring to obtain complete dominion over the State is over two months, or about the same as it requires to pass from northern Florida to central Michigan. The earliest date is February 28, at Hatteras, the latest May 10, at Blowing Rock, in the highest region of the Blue Ridge. The line for April 1 is 50 miles within the coast which it follows, and that for May 1 is very irregular and is chiefly governed by the topographical features of the Great Smoky mountains. Thus, over a large portion of North Carolina spring arrives during April. The popular saying in this State is that the leaves always attain their full growth by May 10, then summer holds undisputed sway.

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[a] Similar facts were brought out in Harrington's paper, already referred to.

LIGHTNING RECORDERS AND THEIR UTILITY IN FORECASTING THUNDERSTORMS

By Mr. JAMES KENEALY, *Cleveland, Ohio.*

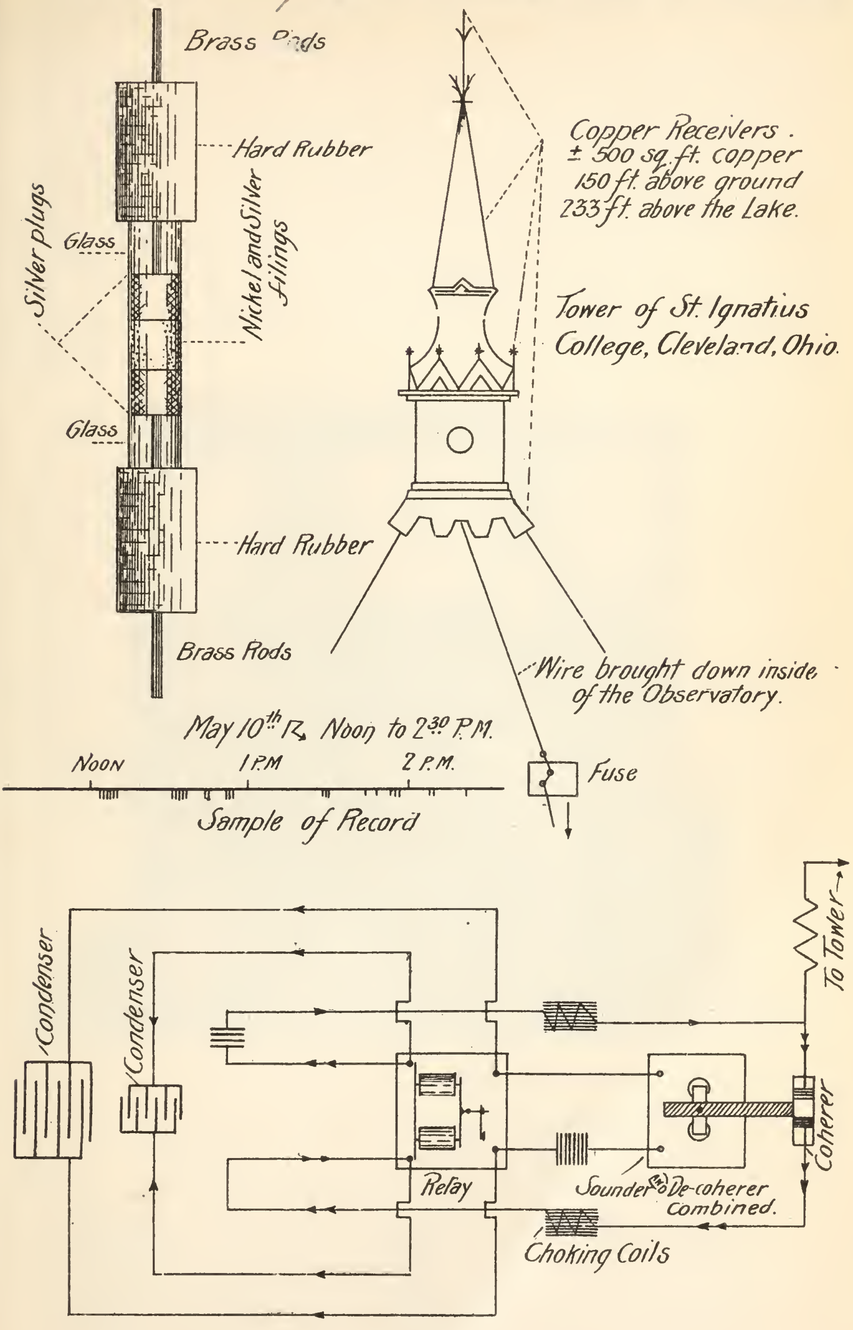
[Read by title.]

In the investigation and the study of electricity, during the past few years, particular attention has been given to the properties of electro-magnetic, or Hertzian, waves. The experiments made with the view of applying this form of electrical energy to practical uses have had chiefly for their object the transmission of signals by some one of the many systems of wireless telegraphy. I wish to invite attention to another application which I believe will be of especial interest to meteorologists.

Three years ago a well-known maker of scientific instruments—Ducrete, of Paris—noticed that an instrument which he had constructed for the purpose of sending signals by a certain system of wireless telegraphy responded to flashes of lightning. Later—about a year ago—Boggio Lera, of Sicily, succeeded in obtaining records of lightning flashes, by using a receiver constructed according to the plans of Marconi, and since that time Professor Rizzio and Dr. Pochettino have made use of similar lightning recorders at certain European stations, where the efficacy of the shooting of cannon against hailstorms was being tested—the stations of Casala and Colegniano. The exact construction of these recorders is unknown to the writer, but it is probable that the instruments are described in "Comptes Rendus, CXXXI, No. 22, November 26, 1900."

In the city of Cleveland, about a mile in a SSW. direction from the office of the United States Weather Bureau, there is a Jesuit college, of which the scientific department and observatory are in charge of the Rev. Father F. L. Odenbach. A few months ago it occurred to Father Odenbach that he could probably obtain records of distant thunderstorms by the use of the copper-capped tower of the college as a collector. This he has succeeded in doing. The instrument he employs includes what is known as the Lodge coherer, an ordinary relay of 50 ohms, and a sounder. For the benefit of those who may be unacquainted with the construction and nature of a coherer, I will state that it consists essentially of a break in a circuit, the break being filled in with a metallic powder that offers an infinite resistance to a voltaic current, but under the influence of lightning flashes this resistance breaks down. In explaining the action of the coherer, Father Odenbach states that its high initial resistance is due to a film on the surface of the metallic particles, and that the reduction of resistance by electro-magnetic waves is due to some kind of electrolytic transfer of ions across this film, resulting eventually in a deposit of ions in the form of bridges over the gaps, whereby the particles are connected with one another and form a conductor. This explanation, he states, is in accordance with the views of such authorities as Lodge, Arons, Slaby, and Van Gulik. Within the circuit is placed a relay, and, at the least breakdown of the resistance, the sounder, which is connected with a secondary battery, is shunted in by the relay, gives the signal, and decoheres the powder. The decohering of the powder is caused in this instrument by the tapping of the lever of the sounder, which at the same time moves the pen that makes the record.

Plate XXXVI. Diagram of Lightning Recorder and Connections.



Diagrams showing the plan of the lightning recorder, including the coherer and the copper collector on the tower, together with a sample of the record, are herewith shown. (See Pl. XXXVI and fig. 5.)

The instrument is yet in an experimental and imperfect form, but it is expected that an improved coherer will soon be substituted for the present one, which, however, has given fairly satisfactory results.

A set of very interesting records of 32 thunderstorms has been obtained this season since June 1. Data obtained therefrom have been tabulated, and are given below, showing the dates and times of first register of lightning flash and the times when the first thunder was heard, respectively, at the college and the Weather Bureau station. From these data it appears that in many cases lightning flashes were registered one to nine hours in advance of the first thunder heard in the vicinity of the college or the station of the Weather Bureau.

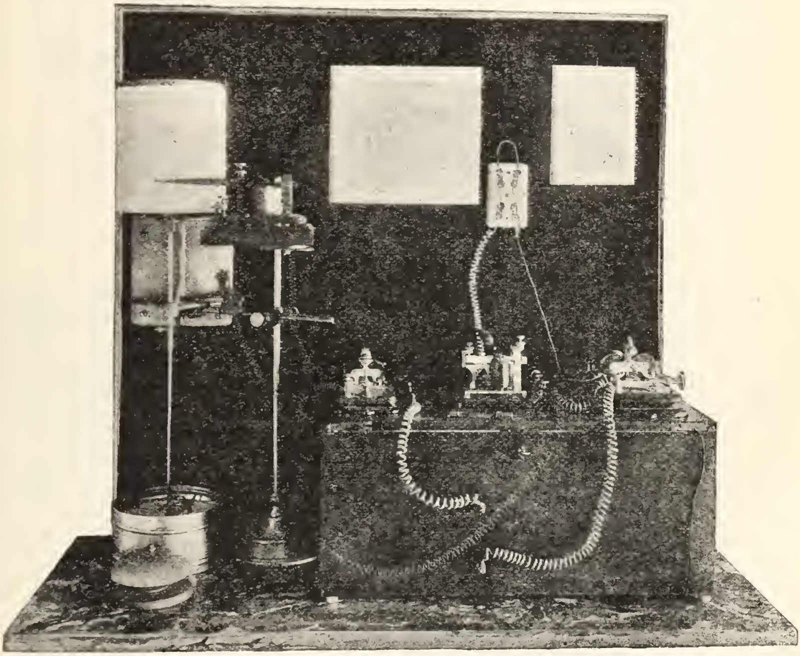


FIG. 5.—Experimental form of lightning recorder.

Date.	First register.	Thunder first heard in vicinity of—	
		College.	Weather Bureau.
June 1	2.45 p. m.	5.40 p. m	5.40 p. m.
2	12.20 a. m	3.10 a. m	3.48 a. m.
5	4.05 p. m	5 p. m	None.
8	1.30 p. m	None	Do.
9	2.55 p. m	do	Do.
10	6 a. m	7 p. m., over lake	Do.
11	12.50 a. m	4 a. m	2 a. m.
12	11 p. m	12.45 a. m	1.15 a. m.
13	12.10 p. m	1 p. m	12.47 p. m.
14	11.10 a. m	None	None.
15	11.55 a. m	12 noon (?)	Do.
17	12.10 p. m	1 p. m	12.47 p. m.

Date.	First register.	Thunder first heard in vicinity of—	
		College.	Weather Bureau.
June 19	2 a. m	9 p. m	9.30 p. m.
19	11.45 a. m		
19	9.20 p. m		
20	12.30 p. m	1.15 p. m	2.15 p. m.
20		9 p. m	12.40 p. m.
21	12.05 a. m	4 p. m	3.42 p. m.
22	7.05 p. m	7.15 p. m	7.25 p. m.
24	6 p. m	None	11.43 p. m.
25	1.15 p. m	do	12.10 a. m.
July 1	12.10 a. m	do	None.
2	8.10 a. m	do	([a]).
3	6.05 p. m	do	None.
4	9.35 a. m	7.45 p. m	2.15 p. m,
4	7.15 p. m		6.53 p. m.
5	5.35 p. m	11.50 p. m	5.54 p. m.
		10.15 p. m	
11	12.30 a. m	12.50 a. m	12.55 a. m.
15	11.00 a. m	5 p. m	5.42 p. m.
16	3.15 p. m	None	3.27 p. m.
17	3.30 p. m	do	([a])
21	6.25 p. m	do	([a])
24	4.05 p. m	do	Early morning.
26	2.25 a. m	3.30 a. m	2.10 a. m.
26	11.15 p. m	3.55 a. m. of 27th	11.50 p. m.
27	12.30 p. m	12.30 p. m	12.50 p. m.
27	3 p. m		5.30 p. m.
30	11.05 a. m	None	None.
Aug. 5	5.20 p. m	do	Do.
14	8 p. m	1 a. m. of 15th	Do.
17	2.05 p. m	3 p. m	Do.
18	2 p. m	3 p. m	Do.
19	1 p. m	4 p. m	Do.
20	10.15 a. m	1 p. m	Do.

[a] Distant lightning only.

It can scarcely be doubted that results of great value will be obtained from the comparison and study of such records as these in connection with collated reports of thunderstorms in the surrounding region within a radius, say, of 100 miles. The problem of determining the exact locality in which any of these silent and invisible forces has its origin must be classed with the many other problems concerning whose solution expectation is now on tiptoe. It would seem that under certain conditions of atmospheric pressure, temperature, and humidity the lightning recorder should furnish valuable aid to the forecaster, more especially during the periods when the daily weather map indicates a possibility of the formation of thunderstorms in the region immediately west or south of the station, while no report of the actual occurrence of a thunderstorm has been received from any station in the section.

THE CAREER THE WEATHER BUREAU SERVICE OFFERS TO YOUNG MEN.

By Mr. Roscoe Nunn, *Nashville, Tenn.*

[Read by title.]

The Weather Bureau service appeals to men whose aspirations tend more toward a life of study and intellectual employment than to financial achievements, though what might be termed "business judgment" is certainly an important qualification for the higher positions in the service. It appeals to men who are content with a modest living, but who are desirous of occupying useful places in society. My object in writing this paper is not to try to induce outsiders to seek positions in the Weather Bureau, but to address especially the young men who are my contemporary observers.

In choosing his life work, a young man of worthy ambition and true ideals will ask these questions concerning any calling that may be suggested: (1) Is it honorable? (2) Is it worthy of one's best efforts? And then he will ask: (3) Is there opportunity for advancement and does it promise to reward with a fair degree of success the devotion of one of such ability as I may have?

If the first question suggested should be asked concerning the Weather Bureau service, the affirmative answer could be given very readily. Certainly no calling can be more honorable than one which seeks to develop a science and make practical use of it for the benefit of all mankind; a science that has so far passed the experimental stage that the National Government has for over thirty years maintained a meteorological service for the benefit of its citizens, while at this time all the civilized countries of the world have similar services. Employment in any department of our Government is certainly honorable, but a position in one of the most important scientific bureaus is particularly desirable; so that, in this case, the question, "Is it honorable?" is satisfactorily disposed of with a moment's thought. The second question, "Is it worthy of one's best efforts?" is also easy to answer. It should be sufficient to recall the names of some of the distinguished men—scholars and scientists of world-renowned ability—who have devoted their great talents to the advancement of meteorology—Maury, Redfield, Espy, Loomis, Ferrell, Scott, Hann, Abbe. If these men found it worthy of their earnest labor, surely the average young man need not have any misgivings as to the worthiness of the calling. But the actual, material results of the Weather Bureau service—the great benefits accruing to commerce, agriculture, and the general welfare—show every day that the men who labor to bring about such results are engaged in a work of a high order.

The Weather Bureau is now so thoroughly established and its machinery so well organized that one entering the service has a very desirable career open to him. It offers a promising field for the young man of scientific tastes and training, a field for hard work and study, a field of great usefulness; and to those who shall bring the powers of invention, thought, and industry to cultivate and discover the vast riches of this field there are high honors and rewards more satisfying than gold.

As to financial success in the Weather Bureau, it is limited, as, of course, success in any salaried position must be; also, rewards are not so great as in some other callings. But to one of average ability and industry a fair salary is insured during satisfactory service, while the higher positions in the service pay more than the average professional or business man earns. It must be admitted, however, that opportunities for advancement are not so great—possibly not so frequent—as in some of the larger departments of the Government service, and certainly in many of the large private corporations there are opportunities for men of ability that far exceed any possibilities in the Weather Bureau.

It is a comforting assurance that in the Weather Bureau one is advanced according to his merits. With the assurance of permanence of employment and promotion for merit, one can contentedly devote all his energies to the improvement of his talents and the upbuilding of the service.

One is required to stand a fair examination for entrance as observer; if one receives an appointment, it is probationary—one is assigned to a station on trial for six months. It is the duty of the official in charge

of that station to make the strictest monthly reports on such probationary appointee as to his fitness to continue in the service, and unless the reports are satisfactory to the chief of the bureau the probationer does not receive a permanent appointment. There could hardly be a better system for keeping unfit men out of the service.

Of the several progressive steps that have recently been taken, I think none will prove more helpful to the service than the inauguration of courses of study and examinations for promotion. This step undoubtedly meets with the hearty approval of all those who are really willing to abide by the merit system and who are truly desirous of improvement in the personnel and efficiency of the corps. These examinations are good tests not only of the mental ability of the employee, but of his energy and industry; if one is unwilling to prepare for these examinations he is likely to be unwilling to do many other things that reasonably might be required of him in his daily work. The pursuit of these studies is also an excellent thing to train one to habits of study—and students we certainly must be if we expect to go forward. Such requirements as these are encouraging to the young men of ambition, energy, and ability, for they help to keep the service purged of the indolent and incompetent and make room for the meritorious. Every such progressive movement raises the service to a higher plane and inspires right-thinking young men of the lower grades to increased endeavor and higher hopes of honorable and successful careers.

Observers on station have exceptional advantages for independent effort in the way of study and investigation. One can find time for study, and the nature of an observer's duties are such as constantly to encourage him to endeavor to enlarge his fund of general information and particularly his knowledge of the sciences.

To some the field of action in this service may seem limited or barren, but this is certainly not true. The longer I remain in the service the broader and richer the field appears. There are opportunities on every hand for extending the work and accomplishing good. The public has not yet learned in how many ways we can be useful, nor have we ourselves; but, as the varied character of our work becomes better known, the public call on us oftener and oftener to fulfill our mission as public servants, and, as we study the needs of the various industries of our land in their relation to climate and weather conditions, we constantly find new ways of increasing our usefulness. It is being discovered that the Weather Bureau, with its meteorological records, climatological data, daily forecasts, special warnings, climate and crop service, etc., can be of benefit to almost every kind of commercial and agricultural industry.

It is the duty of the Weather Bureau official to assist the public to an understanding of the value of the service and a proper appreciation of it. Let it be known that we have something of value to give and that we are always anxious to comply with any reasonable request.

I am of the opinion that the greatest immediate improvement of service that could be accomplished would be the training of the Weather Bureau officials to the highest point of alertness and expertness in the use of the knowledge and machinery that we already have. Discoveries of new and important laws may be near or they may be distant; but while ever looking to this end let us not fail to recognize the importance of the quickening of the working corps and the perfecting of systems already in use. To the greatest extent this kind

of improvement depends on the individuals of the service, and the young men who hope to rise to higher places should realize this and profit by putting the suggestion into practice. The successful Weather Bureau official must think seriously of his duties; must seek out new duties; must train himself to be thorough, exact, expert in all. He must broaden his conception of the Weather Bureau work by study, by investigating the needs of his community in relation to the Weather Bureau, and seeking to make the service of increased value. He must not be satisfied with performing merely the routine duties imposed upon him, but must be on the alert to use every opportunity to broaden the scope of his work.

I should be glad to see every employee of the Weather Bureau, from the highest to the lowest, thoroughly imbued with the idea that our work is of the highest class; that the field of usefulness is very large, and much of it yet unexplored; that every individual is called upon to devote his talents and energies to the advancement of the science of meteorology and the improvement of the service; that our calling is worthy of our devotion; and also let us feel confident that we shall receive full credit and reward for every good thing that we accomplish.

SECTION 2—EDUCATIONAL.

ADDRESS OF THE CHAIRMAN, DR. W. F. R. PHILLIPS, OF WASHINGTON, D. C.

It is my privilege to lay before you the program of this section. It is not my purpose to impose upon your patience anything quite as formidable as an address, the program to the contrary notwithstanding. The papers to be read in this section are apparently divisible into two general classes—one dealing with meteorology as a branch of popular education and the other dealing with meteorology, or, as it is more commonly called, climate, as a biological factor. Of climate as a factor in biological study, one has but to consult a bibliographic index to see how immense is the mass of literature upon this subject and how early in history it became one of absorbing interest. Tell a man of some unfamiliar country, and the first questions will be about its climate—is it healthful, is it productive, what grows there, and what will grow there? These are the subjects upon which interest first centers, all because by long experience man knows that in some way—vague, often apparently contradictory—that which is called climate controls these things. It is our hope to find out ultimately how this control is exercised. In by far the greater number of existing studies of the general problem of climatic control of organic life, the method of investigation that has been followed is that of comparing numerically the different classes of events studied and drawing conclusions from arithmetical correspondences. Inasmuch as this method does not of itself impose any limitations upon the facts compared, except that of susceptibility of being counted, its resulting correspondences or discrepancies can be construed at most only as fortuitous coincidences or accidental contradictions. This method is, however, within certain limits useful, especially as a preliminary process. The scientific method of investigation is that of direct experimentation. Here the facts compared are the apparent results of the energy of one system on that of a different system, and the summation of such results represents numerically the probability of casual relationship.

The laboratory is the present arena of this method. Of hypotheses there are many; of experiments there are few.

Meteorology as a subject of popular education is of so recent appearance that its position in the curriculum of general knowledge is not yet well defined nor are its limitations therein established. What has been accomplished toward giving it a status in the schools and before the public of our country is largely due to the fostering attitude of the Weather Bureau. Considered simply as a mental discipline, meteorology is the equal of many of the other didactic subjects, the teaching of which is justified on this basis. As a study itself it is interesting and even entertaining. The utilitarian applications of meteorology are obvious and need no recital, for there are few occupations to which a foreknowledge of coming weather is not of value. Meteorology has much to commend it as a subject of popular interest. There is, however, in connection with the popular study of meteorology, alike with that of the other sciences, a difficult problem to solve, namely, that of giving to persons that do not contemplate being specialists a knowledge of the science that shall be useful and not mischievous. This problem demands, and I bespeak for it, your serious consideration.

UNDER EXISTING CONDITIONS OF STATION WORK, IS IT PRACTICABLE TO REQUIRE ASSISTANTS TO PURSUE A SYSTEMATIC COURSE OF METEOROLOGICAL STUDY.

By Mr. G. N. SALISBURY, *Seattle, Wash.*

I feel that it is necessary to preface my paper with the statement that its contents are neither so broad nor so deep as this voluminous title would indicate. Probably the subject might be better treated by a professional educator or some one who has had experience in educational matters. I hope the experts here present will not be uncharitable. The paper may appear trivial to them; it is not intended for them, but is intended to voice the views of the plodders in the service—the assistants on station and the young men of the service. My desire is always to champion the cause of the young men in the service, and my hope is that they may enjoy the benefits that I in my early days failed to enjoy.

The employees of the Weather Bureau, particularly the officials on station, come before the public in many ways, such as in answering requests for information, in newspaper interviews, in their section publications, and in lectures to educational institutions and societies. The desirability of a broad general education, to which is added a thorough knowledge of meteorology and its kindred sciences, is at once apparent.

The central office has recognized this desirability, study has been encouraged, and certain facilities have been provided for the prosecution of such study as will tend to keep the observer on station in touch with his work. Yet it must be acknowledged that at the greater number of stations the opportunities are very limited, both as to time and facilities, and the obstacles in the way of successful systematic study are difficult to surmount.

First of all, there is no school of instruction for the probationary appointee, who comes directly to the station to acquire practical knowledge of his duties and to study meteorology as he has opportunity. This often seems to impose a hardship upon the official in charge, increasing his care and responsibility without lessening the

burdens of the station for the time. Yet it may be questioned whether a special training school would have advantages over the present method. According to the experience and recollection of the writer, the graduate from the six months' course at Fort Myer (the quondam training school of our service when under military control) generally appeared at station a novice, no better fitted for his practical duties than the probationary appointee now is on his assignment. Six months were thus in a great measure wasted, unless we except the supposed benefit of discipline. Some have maintained that it was the "Myer training" that so firmly implanted the conservatism of method and the "staying power" that so many of our good old officials are remarkable for.

It is probable that if a training school were established now it would be much more practical, more directly fitted for its purposes, and in any case free from the objections that characterized the former institution at Fort Myer.

Since the civil service has been extended to include the station force, new appointees are immediately assigned to station duty. In some cases these men are quite liberally educated; in others they have little more education than is necessary to pass the civil service entrance examination. The combined result is a second obstacle to systematic study. We have in the station force an unhomogeneous body—men with varied attainments. (1) Some who on entry into the service were of liberal education and have since extended it; (2) some who at first had limited education, but have since improved it, or at least have become well-informed and skillful in their practical work; and (3) some who are of limited education, but are anxious to improve. Nor should the fact be lost sight of that there are in the Bureau a number of excellent officials who have given many years to the service who in the ordinary course of events must soon begin to feel the infirmities of declining years. From them there can not be expected as much in work and study as of the young and vigorous, yet the practical knowledge gained by years of experience gives them a value in the service not to be attained at once or for several years by the newer men.

Now, the question under consideration becomes: How, without losing sight of our public duties, can the systematic study of meteorology and kindred sciences be pursued on station and what course is best adapted for such a diversified body of men? That such study will improve the power for usefulness of the officials and increase their interest is almost incontrovertible and need not be discussed. All have the desire to improve—the desirability is self-evident—and yet several obstacles to any uniform scheme present themselves. Most important of all, the main purposes of the Bureau, the daily practical service of the public, must not in any manner be neglected.

It would seem, at first thought, that any time taken for study from the regular hours of duty might be considered contrary to the principle which demands the highest usefulness to the public. It is essential, to be sure, that the daily routine be gone through with, that the records be kept up, and that the information at the disposal of the office be given the widest practicable dissemination, but much of the distribution can always be done by messengers and more economically by mail. It seems unnecessary that every member of the force should be constantly engaged in the routine of clerical work. Much better service can in many cases be given if a reasonable time is taken for reflection and study. Some might urge that the Government can not be justly called upon to educate its employees; that they should

be sufficiently educated beforehand. There are three answers to this: (1) The individual of high educational attainments, if otherwise well fitted, can usually command a higher salary elsewhere than the Government usually pays. It is, therefore, more economical for the Government to employ men of but fair education at very moderate salaries and gradually educate them as required, increasing their salaries as they become more and more useful. (2) There are few, if any, facilities for acquiring on the outside the special education and training needed by Weather Bureau officials. (3) Other departments of the Government do educate their employees in the lines of work peculiar to their employment or service.

It is self-evident that the better informed the official is, other things being equal, the better work he can do for the public. Untrained persons, under proper direction, can do much of the routine, but it is always necessary that there shall be a force in training, preparing for higher work, as exigency may require. Observers are not mere clerks whose duties are to drudge a specified number of hours, but officials who, with discretionary power, often render higher service. The highest public utility is, I think, the keynote to the situation, and is the justification for spending a small portion of office hours in a regular course of study.

The study, to be effective, should be regular and systematic, not desultory. Many an official has attempted, as he could snatch the time, to read the various works on meteorology and cognate sciences in his station library, but duties would intervene, distractions would occur, and perhaps the study be finally abandoned in despair. But above all things else the course should be regular. It should present the latest developments in meteorology, and should be so articulated with the current work as to explain and develop it.

In no other way can the study be so well prosecuted on station as under the direction of the central office. In that office are centralized the results of series of investigations, from the earliest to the latest; there new investigations are constantly being undertaken; there, collected in the Weather Bureau library, is all that has been published in this country and the most worthy publications of other countries upon meteorology and cognate sciences. Translators of French, German, Spanish, and the other languages are there available, by whose aid the newest and best that is in the works of European writers can be culled and collated for the benefit of our Bureau. There, officials of long experience, who know how to select what is most valuable to the student, and separate the essential from the unessential, can weave such select material into a course of instruction which would embody what is valuable and progressive of their own studies and investigations, as well as those of advanced scientists in foreign countries. Unless the reading of the observer-student is directed by competent persons, he will inevitably waste much time and energy in absorbing what is valueless to him.

I should consider it advisable, after the officials have read the books now supplied their station libraries, with the addition of a good work upon topography—especially the topography of the United States—and perhaps some other works that might appear desirable, that a course of lectures upon atmospheric dynamics should be provided. This course of lectures should be extended to include other topics of interest and importance, particularly the relation of plant growth to its meteorologic environment. In meteorology it would be well to develop fully the problems that are most intimately associated with

the work of forecasting. These lectures should also consider the general principles of climatology, the dominating idea being always to give as complete an exposition of the subject of weather processes, as full a knowledge of climatology, and as varied and useful a familiarity with cognate science as time and facilities will permit.

METEOROLOGY IN THE PUBLIC SCHOOLS—HOW MUCH SHOULD BE ATTEMPTED—METHODS OF TEACHING.

By Mr. F. P. Chaffee, *Montgomery, Ala.*

In my opinion meteorology should be taught in the public schools, for, while the higher institutions of learning may be as the nerve centers of the great system on which the political, commercial, and scientific welfare of the country largely depends, our very complete public-school system more nearly reaches the entire mass of the people. It is, as it were, the great artery from which the intellectual and commercial force of the country is drawn.

In a great many of the common schools, elementary human physiology, natural philosophy, and chemistry are taught. These studies to a certain extent interest the student in the temperature, weight, and humidity of the air, yet it would seem that a more intimate study of meteorology could be made interesting, instructive, and beneficial. In fact, were it not that the science of meteorology is comparatively of such recent origin, we might wonder at so little attention being devoted to the study of the air in which we live and on which we depend for all that makes life pleasant.

Assuming that meteorology should be taught in the public schools, the next question is, How should it be taught and to what extent?

While it is not necessary or desirable to disturb the progress which this science is making in the higher institutions of learning, it would be well in the meantime to begin at the bottom. Quite a proportion of the students in the public schools, particularly the males, are obliged to leave school after passing through the fifth or sixth grades, while a still larger proportion have to seek employment before passing through the high schools. Now, it is toward this class, the great mass of students who go to make up the commercial brawn of our country, to whom the practical meteorology of the Weather Bureau would be of advantage, that attention should be directed.

It is a fact, one which will be recognized by any experienced official here present, that persons who visit the Weather Bureau offices, and who have the work of the Bureau and its problems explained to them, become more interested in the Bureau, pay more attention to its bulletins, and make greater use of the information in their vocations. So, for this utilitarian reason, if for no other, a familiarity with the work of the Bureau, which would be engendered by having the study of meteorology taken up in the public schools, would give great returns for the efforts incident to properly starting such a work. All that is needed is a start, and, like many other lines of study the advantages of which were once doubted, meteorology will take care of itself.

This is a practical age. So much has to be crowded into our short lives that each one of us can not afford to learn entirely by personal experience; indeed, to do so would be a wasteful use of time and energy. To keep abreast of the times, we must profit by the teachings of those who have the experience which the ordinary layman

has not the time to gain. Now, the Bureau has a corps of experienced workers, to many of whom the study of meteôrology in its current phase has been a life work. These men, well distributed over the country, should each be a center from which to stimulate an interest in the study of meteorology in the public schools.

It is no difficult task to interest both teachers and pupils in some of the simple problems of meteorology, which to us, by constant association, may seem of but little general interest.

First, the matter should be properly presented to the heads of public instruction—the county superintendents of public schools, or, as termed in other portions of the country, the county commissioners. They should be made to understand that the nearest Weather Bureau official is willing to appear before the teachers' institutes to outline this work and to visit the various schools for a similar purpose. Also, that both teachers and pupils will be cordially welcomed at the nearby Weather Bureau station, where the work and aims of the Bureau can be better explained. The teachers should be shown the advantage of bringing the subject before their pupils. In a conversational way at first, by inviting their attention to any unusual weather changes, and the causes of these changes, as shown by the weather maps and bulletins. Then in the schoolroom, with an ordinary thermometer, a tin pail, 5 cents' worth of ice, and a handful of salt, some very interesting experiments can be conducted, showing the formation of dew and frost. Later, by means of a suitable glass tube, sealed at one end, a tumbler, and some mercury, the principle of the barometer can be explained, while, with the ordinary wet and dry bulb thermometers, the study of atmospheric moisture can be taken up. With even such simple apparatus, and a blackboard on which to illustrate the effect of altitude on the barometer, the air movements, the wind systems, etc., it is surprising how little is required to get a school interested in the subject. Later on, the study may be taken up in its more advanced form, but we must begin at the bottom to lay the foundation on which we desire to work.

Unfortunately, the science of meteorology has not as yet developed to such an extent that we have many absolute laws which can be given to the student; but the science has at least reached a stage where it can give some basic facts, which should be more generally understood by the public.

In many of the primary schools very attractive lessons in zoology, botany, and kindred sciences are contained in a series of books on nature studies, under such titles as "Mr. and Mrs. Crab," giving, in the most simple language, the habits of the crabs, how they feed, how they shed their shells, and how they live. Some treat of birds and their peculiarities and others treat of the germination and growth of plants. Each of these books contains interesting information. Now, it would seem that books in similar simple language on meteorological subjects under such titles as, say, "The story of a raindrop" or "The voyage of a cloud," etc., could be made to convey just the information we desire to impart. Even though no eminent meteorologist may develop among the students, still the work will not be wasted; and who knows but the seed sown may bear fruit much greater than anticipated?

The many books on scientific subjects, written in popular style, which have appeared in recent years have done more to stimulate a general interest in the applied sciences than all the purely technical works ever written. The scientist has in reality, in coming down to meet the general craving for truth, raised a popular desire for investigation hitherto unknown.

I think the Bureau would certainly not be going outside of its legitimate work to encourage the preparation and introduction of a series of books on meteorology for use in graded schools. In the meantime good work can be done in promoting an interest in meteorology by a more determined personal effort on the part of the various officials of the Bureau to bring the subject before the public schools whenever opportunity offers.

DISCUSSION.

Mr. S. M. Blandford (Boise, Idaho). The introduction or the extension of meteorology in the school has a primary and a secondary object. The primary object is to reach the student directly and to give him a true conception of a science that may be useful to him in the ordinary affairs of life. The secondary object is to reach the parent, who has undoubtedly formed opinions regarding the weather and its laws which may or may not be in accord with the best information on the subject. A cross-questioning of the parent by his son will accomplish indirectly more toward changing the parent's impressions, if erroneous, than a great deal of direct argument by persons outside the family.

Fifteen years ago there was practically no thought given to the subject. To the best of my knowledge meteorology was first taught in a very crude way as one of the subjects forming a part of physical geography. At first meteorology was barely mentioned. At the present day thirty to forty pages of the average school physiography are devoted to the subject, and it is presented in such a style that the student secures a fairly accurate idea concerning its elementary principles.

A Weather Bureau official before lecturing to school classes should first inform himself as to the extent of instruction given in the school; otherwise he will be surprised to learn, occasionally to his discomfort, that some of the scholars comprehend the subject almost as fully as the lecturer himself.

A volume not too elementary, but more elementary than Davis' work, would meet the needs of the students of the high schools and academies and be of material service to the teachers. Could not the Weather Bureau undertake the preparation of such a work?

Mr. G. R. Oberholzer (Charlotte, N. C.). I do not think that meteorology is very well treated in school text-books, especially the physical geographies. In fact, the average physical geography seems rather to treat the natural sciences as a collection of curios than to attempt to teach natural laws. Text-books are deficient in this respect, and the reason is that people wish to have that kind of books, and the makers will continue to print the kind people will buy. I think the way to introduce meteorology into the schools is through the teachers. The extent to which the natural sciences are taught in the public schools is gratifying; the best educators are emphasizing the subject and making more and more of it. I do not think meteorology has the standing among the natural sciences that it should have. It offers to the teacher opportunities for instilling into the mind of the child truths regarding things that are all around it, and could be used to great advantage. I asked Mr. Thomas M. Balliet, superintendent of public schools of Springfield, Mass., about the teaching of meteorology, and received the reply following, which I wish to read to the convention, as it embodies the ideas of a practical educator:

We have been trying to teach the elements of meteorology in our primary schools for some half dozen years, and I think we have at least partially succeeded. I may say in the first place that I believe all science teaching in the elementary

schools, and a good deal of it in the high schools, should aim primarily at explaining facts and phenomena in nature which all pupils can observe. There is more educational value in teaching one generalization in physics, for example, and showing the class fifty applications of it in nature and in mechanics, than there is in teaching the same class fifty generalizations, and making either no application or only one application of each principle. The latter is the plan followed in even our best high schools to-day. And the result is that the teaching of science does not open children's eyes to the world around them as much as we supposed laboratory work would necessarily do. To show a class of little children that heat expands solids, liquids, and gases, and then not to use the principle to explain phenomena in nature, is to miss by far the most important benefit which comes from a teaching of science. We may say in general that the best test of all school work is what it stimulates the pupil to do outside of school. With this preliminary point in view, I may say that there are a good many things in meteorology which are of scientific interest, but which can be omitted without detriment in teaching a class in elementary schools.

I believe it is possible to teach the subject to grammar-school pupils to an extent that will enable them to understand the ordinary weather conditions, and to be able to read intelligently a weather map. We have been emphasizing meteorology the seventh year of school. I think we shall push the work up into the eighth or the ninth year, where pupils are, on an average, about 15 years old. I may describe what we are teaching briefly, as follows:

First. In the upper primary and lower grammar grades, there is a record kept in each schoolroom, either on a manila-paper chart or on the blackboard, on which the children record from day to day the conditions of the weather. They also note the phases of the moon and other simple natural phenomena.

Second. In the fifth year of school they have simple experiments on heat and specific gravity, together with other topics in physics not so closely related to meteorology.

Third. In the seventh year of school they make a fair study of specific gravity and heat and the change in specific gravity by heat, and then make the application of it to air movements and movements of liquids. They make experiments with the bicycle pump to show that pressure heats air, and they also make experiments with the thermometer under the receiver of an air pump and notice that expansion cools air. In this way they learn the dynamic heating and cooling of the air. In connection with specific gravity they learn about air pressure and the weight of the atmosphere. There is a barometer in each grammar school. These principles are illustrated by applying them to vertical air currents, the formation of clouds, etc. Incidentally, winds like the chinook and the foehn are explained to illustrate the principles. With these preliminary steps carefully taken, the pupils are in a position to study the cyclonic conditions which determine the weather in these latitudes. The reasons why the air in a cyclone moves in a spiral, and why cyclones move from right to left in a northern hemisphere, and the reverse in the southern hemisphere, are beyond the comprehension of grammar-school pupils. These facts may be given them without an explanation. I am inclined to think that this is the only practicable way to treat them. Having given the spiral movement of air as a fact, the pupils are now ready to see the reasons for the cloud area and for the rain area, and why both areas do not extend equal distances from the center of the cyclone. They can now understand the direction of the wind in different parts of a cyclone, and therefore the change in the direction we have at any particular spot when a cyclone is passing over that spot. They can understand what is meant by a cold wave, and we find it is possible to make clear to them the air movement in an anticyclone and the weather conditions which it brings. We do not find it too difficult to teach many features of the West India cyclones, and I think most of our children in the upper grades comprehend the differences between these cyclones and those which pass over our country from west to east. Incidently we take up the subject of tornadoes and the ordinary thunder storms. I think most of our children understand the connection between these and cyclones. Such subjects as the trade winds and the monsoons can easily be taught in grammar schools.

I should think it a great mistake to attempt to teach the general circulation of the air in grammar schools, as is sometimes done by teachers that do not comprehend how difficult and complicated the subject really is. We have an exceptionally competent corps of teachers, but I do not believe that you would find half a dozen teachers in the city that could give any clear description of the general circulation of the air on the globe. It is therefore a mistake to begin the subject by attempting to describe this general circulation. This is usually done in books and in advanced instruction. I am inclined to think that it is the wrong place to begin.

Another mistake that is often made is to begin in a strictly inductive way the study of cyclones by observing the barometer readings and inferring from these the force and direction of the wind, and from this the temperature, etc. The barometer and the general subject of air pressure are too unfamiliar to young people's minds, even after they have had lessons on the subject, to make that the starting point and then learn by inference that which they find it very much more easy to learn by direct observation. I think this is the general mistake made in teaching meteorology in high schools.

As suggested above, the teaching ought to begin with the study of the direction of the wind, and, as a result, the temperature in different parts of the cyclone. And then the study of the barometric lines should be introduced by way of accounting for the force and direction of the wind.

The study of rainfall, or precipitation in general, is not difficult after the above series of lessons has been given. The subject of ocean currents can be effectively taught after the foregoing. If it is desirable to take up the general subject of climate, the pupils are now prepared to attack that with success.

The question as to how far it is wise to continue such work in grammar schools must practicably be determined by the qualifications of teachers, the maturity of the pupils, and the time which can be found in a course of study for the work.

The weather maps furnished by the Weather Bureau are absolutely indispensable to such work as we are attempting to do. The maps of the Boston weather bureau are in every grammar school and are extensively used.

Mr. H. M. Watts (Philadelphia). I do not agree with those who would force too many subjects upon a child's attention. There is a great idea to-day of teaching sciences to children, but they really get very little out of it. To have meteorology taught in the public schools, I think, would only add another complicated subject to those already taught. Teach the children simple facts, but to introduce the system into the public schools I do not think worth while.

Mr. F. H. Clarke (Scranton, Pa.). I want to go on record as against enlarging the curriculum of the public schools. My experience has taught me that the young men of to-day usually can not write a letter creditable either in composition or chirography. The trouble, I think, is that we are teaching a smattering of a great many things and nothing thoroughly. We are trying to teach pupils too much in too little time, a system that will never accomplish the greatest results.

Mr. T. B. Jennings (Topeka, Kans.). The best way to reach the children is through the teachers, just as Mr. Chaffee has said. You can reach the teachers through their institutes and associations. Get the teachers to bring the children to the office. Tell the children you have an instrument by which they *hear* the sunshine and *see* the wind blow. Now you have got those children interested. They stand by your triple register, and they do *hear* the sunshine and *see* the wind blow. Then there is another point: The Weather Bureau some few years ago sent out a cloud chart. I took some of them to our board of education, and they had them framed and hung in the schools. They got the children interested in keeping a record of the clouds each day, as indicated by those charts—that is, they compared the clouds seen in the sky with the pictures in the charts. They became interested in clouds, and could not see a cloud come up and pass over without comparing it with the chart. They got a very good idea of clouds from that. We must go to teachers' institutes and talk to them just as we would talk before a kindergarten class. The barometer tube, 36 inches long, is all right, but don't use a bucket for a cistern. Take a tumbler, have a cover fitted over it, insert the tube, and make it airtight. Then have two other holes, one through which you can apply a little suction pump, and another through which you can use a bicycle pump. By that means you can illustrate the falling and rising of the barometer as due to difference in the pressure of the air. They get the idea exactly. They know that when

air is forced into that cistern the mercury is forced up the tube, and the reverse.

Mr. Patrick Connor moved that Mr. Jennings be appointed a committee to get up a pamphlet describing the construction of simple apparatus for distribution to pupils in the schools.

The Chairman. I think that the ingenuity of any teacher should enable him to devise such apparatus, and that Professor Marvin's circulars (Instrument Division circulars) give all the necessary suggestions.

Mr. J. Warren Smith (Columbus). I think the Bureau should issue a pamphlet of, say, 100 pages, for distribution to teachers as an elementary text-book on meteorology.

Mr. A. E. Hackett (Columbia, Mo.). Many of the teachers of the common schools come to the summer school at Columbia, Mo., and most of them come to the Weather Bureau office. I explain the use of the instruments to them, but they rarely carry away correct ideas of the value of the records or the uses made of them. I think some simple discussion of the phenomena of the weather, in a form that could be handed to them, would be very useful. Such a pamphlet they could take home for study.

METEOROLOGY IN COLLEGES; TO WHAT EXTENT IS IT TAUGHT AT PRESENT; SHOULD IT BE OFFERED AS AN UNDERGRADUATE OR AS A POSTGRADUATE COURSE?

By Mr. G. A. Loveland, *Lincoln, Nebr.*

More courses in meteorology have been offered in the colleges of the United States in the last year than ever before, and probably still more will be offered next year. Yet the instruction now given is almost insignificant compared with the commercial importance of the subject.

There are two principal reasons why meteorology has made such slow progress as an important branch of study in the colleges and universities. First, the teachers do not care to teach it. Secondly, its commercial value, or its value as an educational asset, has not been sufficiently realized. Let me explain these statements more fully. Those who decide what shall be taught in the colleges either have not introduced meteorology into the curriculum at all generally or have not encouraged students to take it when it has been offered, one reason being that often none of the faculty cared or had time to teach the subject. In fact, meteorology has not been developed by school men; that is, the professional teacher in the experimental laboratory, studying the science from a love of it, using the subject as a culture study, and imparting his enthusiasm for it to the students with whom he comes in touch. It has rather been developed by a few scholarly men at the demand of commercial interests, and therefore from a utilitarian rather than a scientific standpoint. It has been necessary to render an equivalent in practical money-saving results to the commercial interests to procure the money to continue the work. These men are more like business men than teachers, and they do not come in touch with the youth of the land as the teacher does, so they have little influence upon a student's choice of a course of study.

The demand for meteorological experts has been too small to cause a large demand for instruction in meteorology, differing in this respect from some of the other practical sciences, in which instruction has

grown so rapidly in recent years. The business man accepts what good he can get from weather forecasts. It is enough for him to appreciate the work of the meteorologist without realizing that increased attention to the subject in institutions of learning means both more competent specialists and a more intelligent use of the specialist's work.

Of the more than 400 institutions authorized to give collegiate degrees in the United States less than one-third offer a course of instruction in meteorology; and as far as I have been able to learn, in only one of these does a teacher give all his time to the subject. In most of them only a small part of a teacher's time is available. In fact, with a few exceptions, whether meteorology is taught or not depends upon whether some one in the faculty (or an obliging official of the Weather Bureau) can add the work of giving this course to the duties for which he is specifically employed. Of course, under such circumstances the department never becomes large nor the course of study extended beyond the elemental stage. Often even this course is given in the form of lectures, to which is added a little practical work on the part of the student, sometimes without any attempt at practical work. Under such conditions no department of instruction can become large or really efficient, or contain enthusiastic students.

To increase the general knowledge of meteorology is to increase the efficiency of the Weather Bureau. Can this increased knowledge of meteorology be accomplished best by an undergraduate or a postgraduate college course? There is only one answer—by both courses. An undergraduate course is essential; the postgraduate course will come in time, if the first is successful.

The undergraduate course should be sufficiently extensive to give students a good working knowledge of meteorology, but not so extensive as to require too much of their time to complete it. Under present conditions, most students feel that the number of subjects they must take is so great that if meteorology requires more time on the schedule than it appears to be worth they will get along without it. But the work must be sufficient, and must cover the subject so completely that the student will feel that his time has been well spent. The planning of the courses in meteorology is, I fear, often responsible for the small classes. Young people are critical, and they desire to spend their time where it can be done to the best advantage. A shorter course with a large class is better than a long, complete course and a small class. The few who wish a more extended course can take it the next term. The number of students taking this advanced course would be greater than the number starting in a course scheduled as equally long from the beginning. The short course would undoubtedly attract some that later would decide to make the study of meteorology a life work, which they probably never would have done without the shortcourse.

The advanced work will be of great value. It is now largely the custom of teachers to give each advanced student a problem to work upon—a problem requiring a large amount of observation and experimental work. This practice trains the mind and adds to the total sum of knowledge on that subject. The work of advanced students is important in developing any science. Meteorology has had but little help from them.

The greatest work that would be accomplished by the short course would be in fitting teachers for the public schools. The teachers plan what shall be taught in the high schools as well as colleges.

The teachers in both have an immense influence on the pupil in selecting his course. It is a difficult task to force a teacher to introduce a course in a subject which he has never studied and which he probably considers of minor importance. When the teachers in the schools become generally familiar with meteorology they will determine its place in the school curriculum. But will a judicious course in meteorology in the large universities fit the teachers of the public schools? Permit me to give a few local statistics: Ninety per cent of the superintendents and the teachers in the accredited high schools in Nebraska are from the University of Nebraska. All but one of the teachers in the State normal school are from the University of Nebraska. True, few graduates of the University teach in the country district schools, but the graduates of the high schools and pupils from the State normal school do. Surely the boast made by some members of the faculty of the University of Nebraska that "we, the faculty, teach the teachers, and through them the people of the State," has a large basis in fact. Probably all other universities can marshal similar facts. A strong department of meteorology in each would be an important step in increasing the effectiveness of the work of the Weather Bureau.

DISCUSSION.

Dr. Fassig (Baltimore). I wish to make one statement with reference to the work of the Johns Hopkins University for the teachers of Baltimore. Two years ago the university planned courses of lectures in geology, meteorology, physics, and botany. The course in meteorology was assigned to me. I had a class of 175 school teachers from Baltimore, and found them a most enthusiastic set of students. Nearly all of those who applied for a certificate from the university for attendance, passed a written examination successfully. I mention this simply as one of the efforts to reach the pupils through the teachers, and to introduce meteorology into the schools by that method.

Prof. Cleveland Abbe. The object of teaching meteorology in the schools, so far as the Weather Bureau is concerned, is multiform, but one thing we must not forget is that we want to eradicate ignorance among the people. The school children go home and talk things over, and little by little we are eradicating ignorance—getting the people beyond the ground-hog and sun-spot stage. These things have still a great hold on the people; but we have been fighting a good fight for thirty years and are making progress. Still, we shall have to fight a while longer before they are buried out of sight.

POPULAR LECTURES ON METEOROLOGY, INCLUDING LECTURES TO FARMERS' INSTITUTES, SOCIAL GATHERINGS, SOCIETIES, ETC. ARE SUCH LECTURES VALUABLE IN PROPORTION TO TIME GIVEN? WHAT SHOULD BE THE GENERAL CHARACTER OF SUCH LECTURES?

By Mr. J. Warren Smith, *Columbus, Ohio.*

During the past ten years I have delivered lectures before many different organizations, and I do not hesitate to say most emphatically that I believe this line of work to be profitable to the public and the Bureau.

There is certainly a great deal of misinformation relative to the work of the Bureau. This is demonstrated by the failure of the general public to recognize that our forecasts are but probabilities; to

know the time when they are made and the period that they cover; also to recognize the basic difference in methods between the Weather Bureau's making of forecasts and that of the wanderings of irresponsible long-distance prognosticators. In order that the public in general shall understand our work and thus receive the greatest benefit from it, it is necessary that they be more fully informed, and to my mind there is no better way to bring this about than by popular lectures. We certainly fail in our duty if an interested visitor leaves our office without a better opinion of the Bureau and a clearer understanding of our forecasts and warnings. The half hour given to one man in our office could just as well be given to an audience of several hundred.

Not long ago I overheard a conversation between a lady and a well-known business man of Columbus about the probable character of the day. It was then about 8 o'clock in the morning. The lady called attention to the fact that the "newspapers" promised fair weather for the day. The gentleman replied that the newspapers only guessed at it, and that he thought "we could guess just as well as the newspapers, the only difference being that the newspapers had their guess published." This gentleman apparently had not the slightest knowledge of the fact that the "newspaper guess" was made from carefully considered observations fully twenty-four hours before his guess was thought of. Men whose work calls them out of doors a great deal can make very accurate predictions of the weather a few hours in advance, but ninety-nine out of every hundred when asked to try making predictions in the morning for the next day will say that they are utterly unable to do it except when the atmospheric conditions are well defined.

The wider use of the weather maps in our public schools and the increased space given to meteorology in the text-books on physical geography are causing our work to be better understood by the younger generations; yet we can supplement this text-book and map propaganda by popular explanations and demonstrations in the shape of lectures. Opportunity should always be given for questions and discussion at the close of a lecture, for in this way we learn the facts that interest the public and the weak points of our own work.

The general character of the lecture must depend upon the audience. One must not give the same lecture before a school, a literary society, or a social club that he would deliver before a scientific organization. Often we reach beyond our audience. We are so familiar with the terms we use that we forget they may be greek to the average listener. The lectures must be thoroughly practical, direct to the point, and couched in plain terms. They can not be too plain. I well remember a lecture before the masters of the Boston high schools which I thought was plain and practical in the extreme, yet up to the dignity of the occasion, when a question was asked which illustrates my point. A gray-haired master of a high school asked, in all seriousness, "Whether a cold wave would be as severe if it should move westerly and rebound against the Rocky Mountains and then come east as it would be if it moved directly east in the first place."

Sometimes it will be found necessary to vary the lecture somewhat after reaching the hall, and even after beginning to talk.

I went into a little town in Ohio, two years ago, to address a farmers' institute. There was a long stage ride, and we did not reach the hall until the speaker that preceded me had begun his address. I had expected to speak to the usual gathering of farmers and their wives,

but found instead not a dozen farmers in the hall. It was in a small manufacturing town on Saturday evening, and the audience consisted almost entirely of young people. A lecture for the benefit of the farmers would have been voted a pretty dry affair by them, and I was consequently obliged to give them an address entirely different from that which I had planned.

The work at farmers' institutes is, to my mind, among the most practical that can be done. In Ohio the name of the Weather Bureau section director is among those of the extra speakers in the State board of agriculture's institute work.

A speaker is invited to the farmers' institutes because the farmers wish to know something about his subject. It is no uncommon thing after talking for three-quarters of an hour to spend half an hour more in answering questions. Here again one must use discretion in selecting his subject. He should familiarize himself with the principal crops of the community and direct his address accordingly. I have a large number of lantern slides, and always use them wherever possible to illustrate my discourse.

In order to carry on the work of his office properly the Weather Bureau official must be familiar with the agriculture of his State. At these farmers' institutes the Weather Bureau official can explain the work of the Bureau, and arrange for a more complete distribution of the forecasts and warnings, at the same time he is meeting the leading agriculturists of the State, learning the crop interests of each community, enlarging the scope of his work, and most certainly increasing its effectiveness.

I urge more farmers' institute work upon the gentlemen present as time well spent and well used.

DISCUSSION.

Mr. E. W. McGann (New Brunswick, N. J.). I had a great deal of experience in talking to the farmers of New Jersey last winter. I was listed to give twenty-three addresses at various institutes held in the State, and never was so much surprised in my life as at the general ignorance of the people as to the work of the United States Weather Bureau. I told them very frankly that they were contributing their share of over a million dollars a year for the support of this service, and it was but right that they should know something of the work done by the Bureau. My subject at all these institutes was forecasting—how forecasts are made and how disseminated—covering the whole ground. The central office kindly furnished me with a full set of instruments, and I had a case made so that I could conveniently carry them all in one box. I started out with some want of confidence, and wrote my lecture out in full, taking about an hour and a quarter to read it, but I found on meeting the other lecturers that they did not read, and I realized that even if you had time to read a dry, scientific lecture to the farmers, they would fail to appreciate it, and you would fail to interest them. So, in my lecture, I talked, using the instruments, and had two large weather maps with a storm depicted on them, large enough to be seen all over the hall. I explained the modus operandi of making a weather map, how observations are taken, how they are transmitted to Washington, and how the forecaster, sitting in his office, was able to foretell the weather for any part of the United States twenty-four hours ahead. You know farmers are great believers in the moon. You will find many of them who

will wait until the moon is full before they will plant lima beans or melons or anything that is going to fruit above ground, while they take the dark of the moon to plant potatoes, so that the tubers will grow. I have known men to lose their chance of a whole crop by waiting for certain conditions, and when the conditions came the weather would be such that they could not plant and the crop would go by. The farmers were very much interested, and the number of requests I have received, asking if I would not come again next winter, shows that they are becoming interested in the work of the Weather Bureau. I think this is one of the most valuable parts of our work. It is the duty of the Bureau to show the people just what it is doing and tell them of the millions of dollars it is saving to the people of this country by its forecasts.

In conclusion I desire to read the following letter, which is self-explanatory:

State Board of Agriculture,
Office of the Secretary,
Trenton, N. J., July 9, 1901.

Dear Sir: As a part of my work in connection with the State board of agriculture is to encourage our farmers, through our farmers' institutes, to a more intelligent study of the business of agriculture, you may be interested to have my opinion as to the acceptableness and value of your recent lectures on the work of the State and national weather bureaus.

Judging from the manifest interest during your lectures and the questions asked, I believe the farmers are studying the questions presented in such a way as will lead to a wider use of the weather forecasts and a better knowledge of the system.

If this result follows, it is evident a practical benefit will accrue, not only by heeding the warnings, but by using such preventive measures against early frosts as are suggested from time to time. And, further, by a study of the whole subject as opened up, chiefly by your lectures, supplemented by the crop bulletins during the growing season, they themselves may be able to introduce experiments and particular methods of cultivation which will increase and save valuable crops. The subject is a most important one, and I congratulate you on your sensible and popular presentation of the same.

Respectfully, yours,

Franklin Dye, *Secretary.*

Prof. E. W. McGann, *New Brunswick, N. J.*

Mr. J. S. Hazen (Springfield, Mo.). In discussing this subject I must necessarily confine myself to a somewhat limited experience, but from such experience I unhesitatingly speak for the affirmative side of this question.

For social gatherings, my experience is that general information concerning the history, work, and aims of the Weather Bureau, with a description of map making, methods of drawing the lines, a definition of the various terms and symbols used, with a general outline of storm movements and the relation of the daily forecasts to such movements, constitutes about what is desired. Where one can use a lantern the value of the talk is much enhanced. A more primitive method—a large blackboard map—may be used successfully to illustrate much of one's lecture. For small audiences, the Weather Bureau charts, furnished all weather offices, make a desirable exhibit, but they will not do for large audiences. Where the audience is composed largely of teachers, I find a desire for more explicit information concerning the map-making process, how best to use the maps in schools, the methods of receiving and distributing meteorological data, and the principles of making forecasts. The various terms and symbols used on the map should be explained. Show them how reports are received and translated and how the map is printed. Give them an explana-

tion of normal storm movements. When you enlarge their understanding of the weather map you create an interest in the work and aims of the Weather Bureau that will bear good fruit.

Show to the farmer that his ability to produce an increased yield and raise a more extensive range of crops depends upon a knowledge of the climate of his locality. Be explicit. Explain to him what the introduction of alfalfa, the soy bean, kafir corn, and new and improved varieties of wheat has done for the farmer of western Kansas and other semiarid regions of the West. Make the matter personal. Illustrate by showing the pecuniary advantage of the knowledge. In a matter of dollars and cents the farmer is as keenly alive to his interests as are we to ours. Make him understand the absolute relation between climate and crops, and prove to him that the restriction of certain crops by certain climatic elements, especially temperature and rainfall, is absolute. "Nature is an exacting mistress." She bounds her corn fields on the north and south by isotherms, and the restriction of her boundaries on the west is as sharply defined by the rainfall line of 22 inches. Of course, the farmer may for a season of abnormal rainfall raise bountiful crops of corn beyond this well-defined limit, but the view of deserted villages and abandoned homes to the west of this line should be a sufficient warning that he can not persistently overstep nature's boundaries and hope to escape the penalty. When the farmer understands how absolutely rainfall and temperature limits successful corn growing, we will no longer see the disheartening spectacle of burned-out corn fields and ruined Western farmers striving to get back to the East. When we have taught the farmer the utter impracticability of attempting to raise corn in a region which receives less than 22 inches of rainfall annually, we shall have given him something of value, and which he will appreciate.

The value of such talks would seem to be limited only by the interesting and practical information you can convey to your audience; but you should not ignore the far-reaching dissemination that may be secured by aid of the press. The newspapers, as a rule, want interesting matter, and it should be your business to see that they get all that the Bureau has to give out. Give them as much of your talk as they want, and if the reporters do not have time to secure a synopsis of your article, take it to them. They will appreciate your courtesy. If your talk has been interesting and instructive to your audience, it will be worth publishing, and will be read by the larger audience reached by the newspapers. We thus utilize the press, by being permitted to use its unrivaled facilities, for disseminating and broadening popular knowledge concerning the work and scope of the Weather Bureau.

Professor MARVIN (Washington, D. C.). I would like to mention, in reference to Mr. McGann's remark about the equipment of instruments he had, that the object of the central office is to supply those who are delivering lectures requiring apparatus with instruments as far as possible. Unfortunately, the instrument division is always in an exhausted state, and we generally allot instruments we expect to purchase long before they are received from the manufacturers. We have no stock on hand, but we have some instruments not in condition for regular observations—not thoroughly serviceable—that can be used for illustrative purposes, and the office will furnish these as far as possible.

Mr. CHAFFEE. In answer to the question whether the time devoted to these lectures before farmers' institutes gives a result commensu-

rate with the time devoted to them, I would say emphatically, Yes. I have had the pleasure of lecturing before schools, farmers' institutes, social and other like gatherings, and in no instance, whether the time devoted to the lecture was long or short, did I feel that it was wasted. The farmer is engaged in a pursuit which we desire to benefit and which the Bureau was organized to benefit, and I have found farmers to constitute the most grateful audience that any official of the Bureau can talk to. Their attention should be called not only to the methods of collecting reports and to the reliability of the data upon which forecasts are made, but to the fact that there are times when it is of the most vital importance to farmers to know what the weather of the coming twenty-four hours is expected to be. Every farmer has had just such occasions. Now, where can he get this information? We have the best means of collecting and disseminating it. We are the most reliable source from which he can get this information, and he should be made to understand this. In every case where I have lectured before any body of farmers I have found the results most satisfactory.

Mr. MITCHELL. All that has been said regarding forecasts and warnings can be emphasized when applied to Florida. We are peculiarly situated there, and, notwithstanding the fact that we are somewhat remote from headquarters and at times detached by telegraphic interruptions, we have never had a failure or a complaint during the past seven years. I am not complimenting myself, but the Bureau. The last legislature appropriated $5,000 for farmers' institute meetings. I had the honor of being elected instructor in the State college last winter, and I expect to be able to use some of that fund during the coming season. Now, when it comes to the distribution of forecasts and warnings, it is doubtless a matter of some importance to those who live in the East, perhaps of less importance to those who live in the subpolar regions, and possibly of importance to the hot interior of Kansas, but to us in Florida it is absolutely vital, and were the issue presented to farmers, "Shall the Weather Bureau or the post-office be abolished?" they would say, "Let the post-office go; we can't live without the Weather Bureau."

Professor MOORE. Mr. Mitchell has the distinction of being the man who was specially commended for a violation of orders. Jacksonville is the headquarters from which forecasts of frosts for the important interests of Florida are distributed. On one occasion there was an interruption of telegraphic communication which he did not know of. At any rate he received no warning from Washington to distribute a frost warning and no authority to make a forecast, but he saw there was an emergency confronting him. The reputation of the Bureau was at stake and his people needed a frost warning, for frost threatened to come, so he violated orders and issued a warning to the State of Florida that was perfectly verified. The Bureau got credit, and he himself was commended.

Mr. CLINE (New Orleans, La.). I want to say one word regarding lectures to farmers' institutes. I do not believe the Weather Bureau official gives more valuable time to anything than to these lectures, and I believe the Department should ask for an appropriation to pay transportation and expenses for this purpose. If we expect farmers to heed our warnings, we must instruct them how to use them. This is the way to instruct them. I find the farmers always interested, just as Mr. Smith has found them. We can instruct them by going among them and lecturing to them.

Professor ABBE. I approve Dr. Cline's suggestion. Perhaps a paragraph might be added to the appropriation bill making it the duty of the Weather Bureau to educate a corps of lecturers to address farmers' institutes.

Dr. FASSIG. I think the object might be accomplished under existing regulations by so timing the visits to farmers' institutes as to correspond with the inspection visits to voluntary stations.

Professor MOORE. In setting aside a certain sum to pay for inspections once in two years the object was to enable the section director to go out and meet the voluntary observers cooperating with the section center, and have his expenses or a portion of them paid. It seems that it is only necessary for him to time his inspections to agree with the dates of the farmers' institutes to accomplish both objects at the same time. We must approach these matters carefully and gradually. Congress has been very fair with us. We have tried in all our estimates to be conservative, and to be sure that for every dollar we spend we can give a good account. I agree with you that it would be a good thing if every section director could have a sufficient allowance to travel and lecture before all farmers' institutes at least once in two years, and we hope that time will come. It will come if we give a good enough account of the money we spend. Congress has given us an increase every year. However, when we come to apportion that increase so as to secure the best returns we always find we do not have as much as we want, so we have not as much for this purpose (the inspection of voluntary stations) as we would like to have. It is better to move slowly and keep our expenditures within economical boundaries than to travel too fast and possibly authorize expenditures that subsequent development may not justify. This conservatism has probably deterred us from asking more liberal appropriations. Probably in the future we shall ask for a little more.

Mr. RICHARDS. It seems to me a good idea to notify your voluntary observers of your visit and ask them to invite their friends to meet you to discuss or learn something of the practical workings of the Bureau. In this way you would bring before many people the working of the Bureau without additional expense.

Mr. LOVELAND. In Nebraska all lecturers at farmers' institutes have their expenses paid. I think this is perhaps the case in some other States. The organization of farmers' institutes is progressing rapidly, and the appropriation is increasing very fast. If the Weather Bureau officials be included in the regular list of speakers I think the State would pay their expenses.

Mr. BERRY. We have at last secured a very small fund for the inspection of voluntary stations, and I hope none of it will be diverted from the purpose for which it is intended. Visit the institutes whenever it is practicable to do so, but not with the expectation of defraying your expenses from this fund, unless the institute is on the way to the voluntary station to be inspected and provision is made for the entertainment of the lecturer. I hope the small sum allotted for the inspection of voluntary stations will be used exclusively for the specific object for which it has been provided.

CLIMATE AND VEGETATION.

By Mr. CHARLES E. LINNEY, *Chicago, Ill.*

The farmers of the United States do a large amount of experimenting each year with new varieties of fruits, vegetables, and cereals. These tests are undertaken with little or no regard to the previous

climatic conditions under which the plant grew, whether it came from the adjoining State or the opposite ends of the earth. Many failures necessarily result, with much loss of time and money. Climatic conditions are unfavorable in most instances, for methods of culture are learned with comparative ease, although many failures no doubt result from unfavorable soils. You can not grow the orange, lemon, banana, or fig outside of our warm Southern States; you can not grow firs, spruces, hemlocks or balsams with profit on our western prairies, nor corn in the more northerly latitudes. And yet climatic conditions are learned with comparative ease and to a certain extent can be governed. Plants by slow culture and gradual extension can be acclimated to regions many miles beyond their usual lines of latitude.

The climatic conditions of the United States are now established with a fair degree of accuracy, and the information is available to all seekers. However, it is only recently that an attempt has been made to give the plant zones. This work was undertaken by the Biological Survey of the Department of Agriculture, and the results were published in 1898 in a pamphlet called "Life Zones and Crop Zones."

Physical geographies have heretofore paid some attention to the question of plant and life zones, but it has been usually very superficial, consisting of an elementary discussion of the climatic conditions associated with certain well known and easily distinguished plants. Thus Houghton says:

> Plants require for their growth certain conditions of light, heat, and moisture, and since the requisite amount of each of these varies with different species of plants, we find in every climatic zone a characteristic flora. * * * Moisture and heat are the prime essentials of vegetation, and it is on their distribution that the distribution of vegetation is principally dependent. The influence of heat and moisture is noticed as we pass from the equator to the poles, or from the base of a tropical mountain to its summit, thus arises a horizontal and a vertical distribution of vegetation.

The horizontal zones of vegetation have heretofore been designated the tropical, subtropical, warm temperate, cold temperate, subarctic, and arctic, each with its distinguishing climate and vegetation, although overlapping each other somewhat. The Biological Survey, however, has given a different division, calling the three life zones of North America the tropical, austral, and boreal, subdividing these into the tropical, lower austral, upper austral, transition, Canadian, Hudsonian, and arctic—seven in all. The tropical is indicated by the region in the extreme southland, including the southern parts of Florida, Central America, the lowlands of Mexico, and the lower Gulf region; the austral covers the whole of the United States and Mexico, except along the extreme north and south, while the boreal covers the entire northern part of the continent to the polar regions, and also a few peaks of the higher mountain systems within the United States.

Subdivided and considered for temperature, the survey finds that the tropical zone is confined within that area which has a total quantity of heat approximating at least 26,000° F. (14,400° C.). This is obtained by considering 43° as the beginning of plant activity. With 43° as a beginning, the effective temperature or degrees of heat (daily mean normal shade temperatures) in excess of this number were added together for the several stations considered in the different zones, beginning when the normal mean in spring exceeded 43° and continuing until it fell to or below that point in the fall. With this as a basis the tropical was found to lie within lines which were bounded by an

annual quantity of at least 26,000°. The lower austral was confined to a region which required a total quantity of at least 18,000° F. (10,000° C.); the upper austral to a region and to plant species which required at least 11,500° F. (6,400° C.); the plants of this zone apparently can not endure daily a summer temperature during six consecutive weeks of 79.8° (26° C.); the transition was confined to a region which required at least 10,000° (5,500° C.), the plants of which were apparently unable to withstand six consecutive weeks of daily summer temperature averaging 71.6° (22° C.); and the Canadian, Hudsonian, and arctic extending thence northward into the polar region, their southern limits being marked by the isotherms for the six consecutive hottest weeks of 64.4°, 57.2°, and 50°, respectively. The conclusion of the survey in regard to the distribution of plants and animals is as follows:

> The northward distribution of terrestial animals and plants is governed by the sum of the positive temperatures for the entire season of growth and reproduction, and the southward distribution is governed by the mean temperature of a brief period during the hottest part of the year.

Vegetation throughout the greater part of the United States lies within the temperate (or austral) zone, and is dormant during several months of the year. It is within this region, however, that our largest staple food crops are produced. Germination and growth are wholly dependent upon the temperature in excess or deficiency of 43°. Adamson says that—

> the development of buds is determined by the sum of the daily temperatures counted from the beginning of the year.

But it is likely that a more accurate expression would be the sum of the daily temperatures from the cessation of winter. Linsser says—

> that the sum of the temperatures above zero centigrade (32° F.), which is necessary for a certain development of similar plants in two places, is in direct proportion to the sum total of the temperatures above zero (centigrade) at the two stations.

The adaptability of plants to climate is so great that it is questionable if the heat units obtained for one latitude would be those required in a more northerly or southerly latitude. Take wheat, for instance; it can be grown successfully within the semitropical zone and thence northward beyond the cold temperate zone, a range of probably 20 to 25 degrees of latitude, and in the northern limit the rate of growth is the more rapid. Hoffman, in a series of experiments at Giessen, Germany, and Upsala, Sweden, found that the time of the blooming of the syringa vulgaris (common lilac) was April 29 at Giessen and June 17 at Upsala. The heat units received were 1,482° and 1,433° C., respectively, practically the same. In the first ripening of fruits, 11 species being considered, the ratio between the two places was as 100 to 82, while for the interval between the first bloom and the ripening of fruits the ratio was as 100 to 93. It is commonly observed, often to the great loss of the farmer, that seeds from plants brought into a northern country from the south produce plants which will not mature, for they are caught by the early frosts, while, vice versa, the northern plants in the south ripen far earlier than the native species. Thus it behooves the seeker after seed to stay as nearly as possible within his line of climatic latitude, or draw from a region slightly to the northward.

It has been found that the average daily temperature in the shade must be above 39.2° F. (4° C.) for sugar cane, and 46.4° F. (8° C.) for potatoes, if one desires to observe the effects of germination and

growth. And the higher the temperature the quicker the germination and growth. Huberlandt found that with a temperature of 49.0° (9.4° C.) it took beet seed twenty-two days to germinate, while with a temperature of 60.4° (15.8° C.) only three and three-fourths days were necessary. With these plants, also, the maximum yields were secured by planting the 1st of May rather than the 1st of March or April.

The temperature records of our principal cereal States show from 2,700° to 3,390° of accumulated heat (above freezing) to be the normal in the period of growth of wheat, rye, oats, and barley; March to June (one hundred and twenty-two days) being the usual time in the Ohio Valley, middle Mississippi and lower Missouri valleys, and April to July in the upper Mississippi and Red River of the North valleys. For corn and other grains, grasses, and fruits, that have a season extending from about March to September (two hundred and fourteen days), 4,665 to 7,000 heat units (above freezing) are the normals throughout the same region.

Rainfall is, next to temperature, the most important climatic element. The amount required for the growth of vegetation has been ascertained many times and for a large variety of plants, but with rainfall, as with temperature, there seems to be a wide range, possibly because plants adapt themselves to their environment. In addition to the amount of rainfall required, it is essential also to know the frequency of fall, the rapidity of fall, and the average amount of each fall. Thus a rainfall of 4 to 5 inches per month would, if it came in showers of a half to three-quarters of an inch, provide ample moisture for the most thirsty farm crop, but if the same amount were dashed down in one or two heavy showers, the results would not be favorable. Other points of value are the probability of rainfall, the length of time rain may reasonably be expected to continue after it has set in, the extent of the country covered, the temperature, humidity, sunshine, and wind before and following the rain, the condition of the ground water, drainage, and composition of the soil, and the moisture characteristics of the plant.

Experiments carried on by Professor King, in Wisconsin, indicate maximum yields of corn with 25 to 30 inches of rainfall during the crop season; oats 15 to 20 inches, and barley 12 to 20 inches. It appears also from experiments in Germany that about 5 inches of water to the ton of dry matter should be sufficient to produce a wheat crop of 15 bushels per acre; 6 inches to the ton to produce 20 bushels to the acre; nearly 8 inches for 25 bushels; 9 inches for 30 bushels, and 12 inches for 40 bushels per acre. Professor King, however, in considering the rainfall of the San Joaquin Valley, the evaporation which would likely occur, and the soil water, thinks that 7.5 inches of water per ton not too much to secure 15 bushels per acre; 9 inches for 20 bushels; 10.5 inches for 25 bushels; 12 inches for 30 bushels, and 15 inches for 40 bushels. From which it would appear that our semiarid West can, during most seasons at least, raise a fair crop of wheat, other conditions being reasonably favorable. Mr. Mark Carleton has recently given like testimony in an article in the Year-Book of 1900, in which he shows that good average yields of wheat are steadily secured by the farmers of Russia in parts having much less annual and seasonal rainfall than our so-called semiarid region.

The normal rainfall during the season of growth of small grain in the Ohio, middle Mississippi, and Lower Missouri valleys is from 11.3 inches to 14.7 inches, and decreases from 10.6 inches to 8.3 inches over the upper Mississippi and middle Missouri valleys to the Dakotas

and Red River of the North, the average wheat yield being from 10 to 24 bushels; oats from 18 to 40 bushels, and barley from 15 to 30 bushels. The normal rainfall from the 1st of March to the last of September decreases from 26.3 inches in the middle Mississippi and Ohio valleys to 24 inches in Illinois and Iowa; 21 to 23 in Michigan, Wisconsin, and Nebraska, and 15 inches in North Dakota. This gives an effective rainfall for the corn season of about 16 to 18 inches in the Lower Missouri, middle Mississippi, and Ohio valleys; 12 to 15 inches in the lake region, Upper Mississippi, and middle Missouri valleys, and from 10 to 12 inches in the Dakotas and Red River Valley. Professor King finds, in summarizing the results which should be obtained from the effective rainfall in our principal cereal States, if the same were practically used in plant growth and grain development, that an average yield of 40.3 bushels of barley, 65 bushels of oats, and 71.5 bushels of corn per acre should be had. These yields are in fact attained by our best farmers in our most favored seasons and on the best soils.

In the year 1895 19.6 inches of rain in Illinois produced an average yield of 37.4 bushels of corn, 16.8 inches of rainfall in Indiana produced 32.8 bushels of corn, 21.4 inches of rainfall in Iowa produced 35.1 bushels of corn, 24.6 inches of rainfall in Missouri produced 36 bushels, and 18.9 inches of rainfall in Kansas produced 24.3 bushels of corn. In the same year 10.1 inches of rainfall in Illinois produced an average of 11 bushels of wheat per acre, 20 bushels of barley, and 24.4 bushels of oats; about 6 inches of rainfall in Indiana produced 9.2 bushels of wheat, 15 bushels of barley, and 22.9 bushels of oats per acre; 13.2 inches of rainfall in Missouri produced 12 bushels of wheat, 15.3 bushels of barley, and 27.7 bushels of oats per acre, and 9.4 inches of rainfall in Kansas produced 7.7 bushels of wheat, 14.4 bushels of barley, and 17.9 bushels of oats per acre. On deep, fertile soils, therefore, good paying yields of small grain may be expected with rainfall as low as 7 to 8 inches, and large yields when the rainfall approaches 12 to 15 inches during the growing season.

Sunshine as a factor in plant growth is probably third in importance, and closely allied to temperature. It is usually determined by the inverse method, observations of clouds and cloudiness, rather than the actual sunshine, although of late years many of our stations are equipped with sunshine recorders, and the approximate hours of sunshine are obtained with a fair degree of accuracy.

The effect of sunshine in determining the form of plants is well known. If a plant germinate beneath a box, board, or stone it does not spread out at random, but takes the shortest path to the sunlight, where it spreads out in its usual form. The form and direction of growth of every branch, leaf, or shoot of a plant is controlled largely by its accessibility to the light. This is true even to the development of the branches, for these bud and grow where the leaves can unfold to the light with the least obstruction, and a symmetrical plant is usually an unobstructed one. The agriculturist should meet this need of light in the planting and cultivation of his fields.

Just how much sunshine is essential has not been fully determined, so far as I can learn, but that plants differ much in their requirement, and also adapt themselves rapidly in this, as in temperature and moisture, is well known. An almost cloudless sky for months will not harm many plants if they have an abundance of moisture, and it is probable that others would be equally immune if they were gradually acclimated. Experiments in Paris, carried on through a

period of five years, in which sunshine, heat, rainfall, and evaporation were carefully measured from March to July, inclusive, showed that a considerable increase in crop yield was obtained when the percentage of sunshine was greatest, although at no time during the period was there a very marked difference in the amount of sunshine measured.

Other climatic elements which can be considered of value in relation to vegetation are wind direction, wind velocity, and evaporation. The wind direction and velocity of all parts of the United States have been determined with reasonable accuracy, and should be available to anyone seeking this information. The damaging effects of high winds can be largely controlled by the cultivation of wind-breaks. These will quickly and permanently prevent drifting of the soil, too rapid evaporation by high winds, broken and fallen grain, due to the same cause, and, to a considerable extent, winter killing. Professor King finds a marked decrease in the rate of evaporation for a considerable distance to the leeward of a row of trees or a hedge. He also recommends for a windy country, where light and comparatively porous soils predominate, small, narrow fields, with intervening fields of clover, alfalfa, or grass, for even these small plants serve as a marked barrier in drifting soils.

The evaporation from soil and water surfaces has not been ascertained with accuracy for a large part of our country. On land surfaces it is found that while evaporation is heavy directly after a rain storm, it diminishes rapidly as the upper layer of earth becomes dry, and practically ceases after a short period of time. In the more modern and skillful farming this is aided by tillage, and if a dust mulch can be maintained evaporation is reduced to a minimum. This seems to be especially the case in our Western States, where a loose soil in itself becomes a mulch. Professor King found that the rate of evaporation in the San Joaquin Valley fell to the small amount of 0.8 of an inch in one hundred days of almost continuous sunshine, and did not exceed 1.5 inches in a second trial at a different season.

If the opposite effect is desired, i. e., more rapid evaporation, firming the soil with a roller to establish capillarity will quickly produce the desired result, except on lands which need underdrainage, when it alone will suffice. Agricultural prosperity is the basis of all prosperity, and its success depends upon the adaptation of the plant to the climate. While it is scarcely the province of the Weather Bureau to determine what plants are adapted to this or that climate, I think I am justified in saying that we will at all times gladly cooperate with the biologist, to the end that this information shall become available to our agriculturists.

DISCUSSION.

Mr. J. Warren Smith. I am sure that the general public does not understand the close connection between the weather and the growth and ripening of vegetation, and I doubt very much if the majority of us in the Bureau appreciate the matter as we should.

Instead of taking the sum total of the temperatures above 40° I believe that we should consider only daytime temperatures; possibly the total insolation must alone be taken as the basis of calculation. Is it not true that the increasing insolation in more northern latitudes causes more rapid growth and earlier maturity than in more southern

districts, while the more rapid growth and increased sunshine produces fruit and grains of a firmer, harder nature?

I would give sunshine a more prominent place than has been given it, particularly in the maturing of crops. Two years ago the sugar beets grown in northern Ohio gave a very high per cent of sugar. Last year there was much complaint on the part of the growers, because the experiment-station test made the sugar content much lower than the previous year. They did not understand why there should be such a difference; neither did the station officials until a visit to our office and an examination of the voluntary observer records in the sugar-beet district was made. These showed much more cloudiness at just the ripening period all through the beet-growing district last year than the year before. A simple thing, yet all important in its results.

It may not be within the province of the Weather Bureau officials to determine the proper climatic location for the various crops, yet I do believe that it is a distinct part of our duties to work out the relation between weather and crop growth. We must not draw conclusions too quickly, but I am sure of one thing: we shall find that the period when crops are greatly injured by bad weather or benefited by good weather to be a comparatively short part of the whole period of their growth, particularly when the yield departs very much from the normal.

I believe it is our duty to the public to make such studies. Then, when the Bureau can make predictions for a season in advance, as I believe it will ultimately do, we shall take our true place in the affairs of the community.

CLIMATE AND MAN: WITH SPECIAL REGARD TO CLIMATE AND CLIMATIC ELEMENTS AS CURATIVE OR CAUSATIVE AGENCIES OF DISEASE.

By Dr. W. M. Wilson, *Milwaukee, Wis.*

The distribution of the climatic elements of a country determines its fruits and flowers, its industries and activities, and the character and temper of its people.

The world's great workshop is bounded by the tropics and the arctics, and neither the torrid zone, where life is made too restful by nature's bounteous provisions, nor the frozen North, where existence must be wrested from the unwilling sea and soil, are conducive to the highest development of the race. Practically all of the world's great industries are centered within the limits of the temperate zone, and thus far every effort to plant a great nation outside this narrow belt has proved a disastrous failure. Gigantic schemes, with elaborate and refined preparations for the colonization of the tropics, have always been met by the insurmountable barrier of death and disease, until the West Indies have come to be called the "Graveyard of Europe."

France has been one of the foremost nations in the promotion of these enterprises, and French literature is full of ingenious explanations for each successive failure, which, after a more or less devious path through the social and political questions of the time, usually arrive at the same fundamental conclusion, that the climatic conditions of the tropics are unsuited to European civilization.

An English authority, Benjamin Kidd, has pronounced in no uncertain terms against the possibility of the white man ever being able

to pass the tropics, assuming that past experience has shown beyond the shadow of a doubt that nature, by the interposition of the deadly climate of the tropics, has placed a natural barrier in the way of further progress in that direction which may not be passed with impunity. With all due regard to these eminent authorities, one who approaches this subject with an unbiased mind can not fail to be impressed by the absence of any attempt to classify or analyze the characteristics of the various maladies which produce such disastrous results and the perfunctory way in which the whole responsibility is placed upon climatic conditions.

The influence of climate upon the origin and cure of disease is a question of very great importance, not only to promoters of industrial enterprises in tropical countries, but to the great army of health seekers that make annual pilgrimages to the famous health resorts in search of a climate which will restore youth or cure disease. It is a matter of common knowledge that most infectious diseases exist only within certain limited areas. Some have their home in the tropics; some, like tuberculosis, acknowledge no geographical limitation, and seem destined to overspread the whole world; while others, like diphtheria and smallpox, are gradually being crushed out by modern prophylactic methods, and may even be tending toward extinction. On the summit of high mountains infectious diseases are unknown, and in the "farthest north" the earth and air and sea are as free from harmful germs as though sterilized in the laboratory of the chemist.

The tendency of diseases to become localized in their distribution has given rise to a general belief that the cause for their origin and propagation must be found in the prevailing climatic conditions, and that for this reason certain climates, especially the tropics, are absolutely unfitted for the habitation of the white man, while others are endowed with healing qualities akin to those ascribed by the ancients to certain springs. During the past twenty-five years, however, scientific experimentation with reference to the origin and propagation of infectious diseases has revealed some startling truths, the discoveries in this field of research undoubtedly constituting the greatest achievements of modern medicine. It is now positively known that many of the diseases heretofore ascribed to climatic conditions result from the presence within the body of a specific germ or living organism, the life history of which is as well known as that of the most common insect, and that by proper hygienic precautions, one may live in the very presence of this most deadly enemy in comparative safety.

The discoveries have a most important bearing upon the subject of medical climatology; for, while climatic conditions may in a measure favor the development and activity of the germs of disease, the responsibility for their invasion of the human body is thus shifted from impersonal, irresponsible climate to a responsible individual, who, when having knowledge of the proper prophylactic measures to be employed, fails in the necessary hygienic precautions, must suffer the consequences of neglect. The thinkers of to-day are gradually reaching the conclusion that the healthfulness of any locality or section is not so much a matter of climate as a matter of hygiene; and when medical science shall have studied the diseases indigenous to the tropics with the same zeal and success that has attended the investigations into the etiology of the ailments of the temperate zone, one can live in a tropical country, under proper hygienic precautions,

perhaps with less personal comfort, but certainly with no more danger, than in the most favored spot in our own country.

Smallpox has few terrors for the present generation, but this scourge has claimed its victims by the tens of thousands. It is not climate, but scientific sanitation and hygiene, that has wrought the change. Yellow fever will no more wreck our Southern cities when the breeding pools of the mosquito are eradicated; and when the so-called climatic diseases of the tropics are as well known and the proper precautions observed that "graveyard of Europe," the West Indies, will become the veritable garden of the world, and the words "acclimated" and "immune" will disappear from our language.

Climate as a cure for disease, in the broadest sense, rests upon the same general principle. A specific disease must be reached by a specific remedy, and, strictly speaking, climate, so far as known, possesses no qualities which would entitle it to such a position in the materia medica. The claims made by the promoters of certain health resorts that the richness of the air in ozone, the resinous gases from the pines, the peculiar purity of the atmosphere in a particular locality, or the elevation or aridity of the air acts as a specific in certain diseases, are not generally based upon scientific investigation, and usually have their origin in the fertile brain of the advertisement writer.

It is common knowledge that the principal components of the atmosphere are in practically the same proportion the world over, that the amount of moisture varies with the locality and season, and that rarefaction results from an increase of elevation; and while it is true that elevation tends toward increasing lung capacity and that excessive humidity retards in a measure the excretory action of the skin, it has not been shown that the absence of moisture has any specific influence upon those diseases for which a dry climate is so frequently recommended, or that a rarefied atmosphere is essential to the destruction of the germs of disease. On the other hand, there is ample experience to show that persons suffering from troubles associated especially with tuberculosis are frequently benefited by a residence in the humid air at the level of the sea as well as in the dry and arid atmosphere of our Western plains.

We must, therefore, look further than to mere climatic conditions for the cause of the cures which sometimes certainly do result from a change of residence. The human organism, both in health and disease, is so complex in its operations, so delicately poised, and the relation of the mind and body so interdependent, that environment, whether it be of climatic or of social conditions, while not acting directly, may, through the senses, exert a powerful influence upon the vital forces. This influence of environment is all the more potent in that class of diseases in which continued ill health and lowered vitality allow the shattered nervous system to respond readily to external impressions, and in these cases a change of residence is frequently of the greatest benefit. Nature itself is the best doctor, and, when supported by environment and proper medication, may be relied upon to use all the forces at command against the inroads of disease. That climate may play an important part in the curative process is not denied, but that the climate of certain localities possesses any peculiar properties which act as a specific on certain diseases is neither borne out by scientific investigation nor unbiased experience.

In the selection of a place of residence, climate should be considered

only in its effect upon comfort and congenial surroundings and with a view to a constant outdoor life. Pure air, which can be found almost any place outside of great cities, and the maximum amount of sunshine are the two essentials.

That the temperature is not important is shown by the excellent results obtained by a residence in the Adirondacks, where the cold of winter is frequently intense. That a dry atmosphere is not essential is evident from the equally good results obtained in the arid climate of our western resorts and the humid atmosphere of the Southern States. That rarefaction is not a requisite is shown by the cures effected both at sea level and at high altitudes. With complete relief from care and anxiety, good food, pleasant occupation, and a constant outdoor life, one may fight a winning battle against disease in almost any climate, whether it be in the arid, rarefied atmosphere of Colorado or New Mexico, the soft and genial warmth of Florida, or the more rigorous climate of the New England States.

INFLUENCE OF CLIMATE ON ANIMAL LIFE.

By Mr. R. H. Dean, *La Crosse, Wis.*

It has long been a common belief that climate is the paramount factor in controlling the abundance and distribution of animal life, and that climate to some extent modifies the form and organism of animals. The limits of this paper preclude any treatment of the last proposition, and only the influence of climate on the distribution of animals will at present be discussed.

The old geographers[a] fixed rather rigid boundary lines for life zones, making of the tropics and arctic circles barriers which bird and beast scarcely dared approach. Some very general laws were recognized as fairly well established, the most important among them being one that stated that the number, size, strength, and beauty of animals decrease from the equator to the poles. Observed facts seemed to support this general belief. Elephants, hippopotomi, camels, tigers, monkeys, and many other species of quadrupeds and the birds of brilliant plumage inhabited the tropical climates exclusively and in great numbers, while polar bears, reindeer, arctic foxes, auks, and a few other animals were found in less abundance in the arctic regions only.

About a quarter of a century ago the study of zoology and kindred sciences received a great impetus from the works of a brilliant array of scientists, and biology became a familiar term. The general tendency of these writers was strongly against the popular belief stated above; and nearly all of them minimized climate as a factor in the distribution of animals, while some of them maintained that it was scarcely a factor at all. Wallace[b] says—

> It was long thought, and is still a popular notion, that the manner in which various kinds of animals are dispersed over the globe is almost wholly due to the diversities of climate and vegetation. There is much to favor this belief.

He then proceeds—

> A more detailed and accurate knowledge of the productions of the different parts of the earth soon showed that the explanation was quite insufficient.

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[a] Swinton's Grammar-School Geography, p. 10.
[b] Geographical Distribution of Animals, p. 5.

And the whole tenor of the excellent and fascinating works of Wallace is to ascribe to other causes than climate the distribution of animals. Other writers held similar views. Darwin,[a] among the more cautious, says—

Climate plays a most important part in determining the average numbers of a species, and periodical seasons of extreme cold or drought seem to be the most effective of all checks. * * * Climate [as a check] acts in the main part by favoring other species.

Thus admitting the efficacy of climate as a check to the increase in number of animals and at the same time giving it a secondary influence.

Heilprin[b] says—

But while in numerous and, perhaps, the majority of instances the limitation of animal groups to certain geographical regions is dependent more upon the physical character of the immediate environment and the nature of the food supply than upon particular conditions of climate, yet it can not be denied that in many cases climate appears to exercise a paramount influence upon distribution.

Semper[c] concludes an argument on the subject with these remarks—

The results thus laid down * * * justify us * * * * in denying the value frequently attributed, even quite recently, to curves of temperature as constructed by meteorologists.

He further says—

Hence it is evident that classification of animals according to the climate in which they live * * * has no real value.

He then adds—

If we assume that if there is a certain degree of heat * * * which is most favorable to the well-being of one or several species of animals, obviously every rise or fall of temperature above or below this favorable point must be to a certain extent injurious to the creature.

This degree of favorable heat Semper calls the "optimum," and makes it the base from which to work. We shall see later how nearly he was approaching the truth.

The problem was and is a complex one. Wallace[d] quoted above, says—

Every change becomes a center of an ever-widening chain of effects. The different members of the organic world are so bound together by complex relations that any one change generally involves numerous other changes, often of the most unexpected kind. We know comparatively little of the way in which one plant or one animal is bound up with others, but we know enough to assure us that the most apparently disconnected are often dependent on each other.

And further he intimates that they may, in the same way, be dependent on the permanency of climate, or vastly affected by a slight change in the same.

Dr. J. A. Allen had shown that, so far as birds are concerned, it is the temperature which prevails during the breeding season that controls this distribution. This was a step ahead of Semper, and an important advance.

Dr. C. Hart Merriam, of the Department of Agriculture, investigated the subject for a number of years, and in 1890, as the direct results of the biological survey of San Francisco Mountain, gave the first fruits of his labors to the public.[e] It is difficult to overestimate the value of the results obtained and the conclusions arrived at.

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[a] Origin of Species, 5th ed., p. 75.
[b] Distribution of Animals, p. 35, International Series.
[c] Animal Life, p. 103, International Series.
[d] Distribution of Animals, p. 44.
[e] North American Fauna No. 3, Department of Agriculture.

No advance toward the establishment of definite laws for the distribution of animals and plants of equal importance had ever before been made. Dr. Merriam found that "temperature and humidity are the most important causes governing the distribution, and that temperature is more potent than humidity."

The investigation has been continued by the Biological Survey of the Department of Agriculture, assisted by other Government bureaus, including the Weather Bureau. As one result, Dr. Merriam has promulgated definite temperature laws which govern not only the distribution of animal life but of plant life as well; and it has been shown that the faunal zones and floral zones are identical, and are also climatic zones. They are not, it is true, restricted by curves of mean annual temperature, the results in this agreeing with what was advanced by Semper; and the time of the temperature is that of the season of growth and reproduction, agreeing in this with Allen on the distribution of birds. But there were yet other intricacies, and it was found necessary to take one set of temperatures for the limit of the cooler side of the range, and another and entirely different set for the limit on the warmer side. These laws, as formulated by Dr. Merriam and published first in the National Geographical Magazine, December, 1894, were, leaving out of account obvious physical barriers, such as oceans—

> In northward distribution, terrestrial animals and plants are restricted by the sum of the positive temperatures for the entire period of growth and reproduction. In southward distribution they are restricted by the mean temperature of a brief period during the hottest part of the year.

It yet remained to determine what temperature is effective for life, above which temperatures may be considered positive, and what is the "brief period" of the hottest part of the year.

Since animal life is generally inactive as far as reproduction is concerned and most plant life is absolutely inactive at temperatures below and near freezing point, 43 F. was assumed as the starting point for the activity of life; and the sum of all the mean daily temperatures above that point from the beginning of the season, when the temperature reached 43 F., till the end of the season, when the temperature again fell to 43 F., was taken as a minimum equivalent necessary for the reproduction and growth of the species of animal or the growth and reproduction of the species of plant in reference to which it was used. In other words, the species of plants or animals which require this amount of heat will be found on the warm side of an isotherm drawn through a number of points platted from the sums of effective temperatures. It may be remarked here that the daily mean of the sum of these effective temperatures is probably equivalent to Semper's "optimum."

Lines platted from the sums of effective temperatures thus obtained were found to coincide almost exactly with the boundaries of life zones established from actual lists of plants and animals; hence 43° has been retained as the most probable point for the beginning of life activity.

A period of six of the hottest consecutive weeks of summer was adopted as a working basis for the "brief period" to determine the limit on the warm side of the zones, and the results thus obtained were so satisfactory that no change has since been made.

Applying these principles and rules, the continent of North America has been divided into three primary transcontinental regions, greatly modifying in principle and outline the regions previously recognized. The regions have been called boreal, austral, and tropical. The

regions are subdivided into transcontinental zones: The boreal into arctic, Hudsonian, and Canadian; austral into transition, upper austral, and lower austral; the tropical region is of small extent in the United States and has not been subdivided.

The results of these recent researches and surveys have been of immense practical value to agriculturists and stock raisers, aside from their purely scientific value, and their utility will increase in proportion to the rate that the principles are understood and applied. As it is with the rainfall of the growing season that the farmer is generally concerned, so it is the effective temperature that is important to him, and with proper investigation he may know what is the effective temperature for each crop cultivated and animal raised.

SYNOPSIS OF COURSE OF LECTURES IN MEDICAL CLIMATOLOGY TO THE SENIOR CLASS MEDICAL DEPARTMENT UNIVERSITY OF TEXAS.

By Dr. I. M. CLINE, *New Orleans, formerly of Galveston, Tex.*

Medical climatology was added to the curriculum of the medical department of the University of Texas in 1893. The lectures have been delivered weekly to the senior class.

The course, consisting of 30 lectures, was divided into 4 sections. The sections and lectures are as follows:

Section 1.—Meteorological apparatus and methods. Four lectures.

1. The measurement of atmospheric temperatures. The development of the thermometer and different forms of thermometers. The exposure of thermometers and the methods used in obtaining extremes and averages.

2. The measurement of atmospheric pressure. The construction of barometers and barographs and the methods used in determining averages.

3. Instruments used in measuring the motions of the air and the manner in which their records are utilized.

4. The measurement of aqueous vapor. The measurement of precipitation. The determination of average or normal rainfall.

Section 2.—Meteorology most essential to the study of climatology. Seven lectures.

1. The origin of the atmosphere and its relation to the earth. The composition and offices of the atmosphere. The relation of oxygen to the animal kingdom. The existence of impurities. The extent and arrangement of the atmosphere as regards the earth.

2. The control of atmospheric temperatures: radiation, insolation, reflection, absorption, convection, and conduction. Difference in absorption and radiation between land and water.

3. The distribution of temperature over the earth and the factors which produce irregularities.

4. The general circulation of the atmosphere.

5. The cyclonic and special winds.

6. The causes of precipitation. The distribution of rainfall over the earth.

7. Weather maps; forecasting the weather.

Section 3.—General climatology and mineral springs. Four lectures.

1. General climatological features of different portions of the earth.

2, 3, and 4. The mineral springs of the United States and the climatic features of the sections in which located.

Section 4.—Applied medical climatology. Fifteen lectures.

1. Climate and disease. The physiological effects of weather changes and different climatic conditions on the human organism.
2. Pathological distribution of climate in the United States.
3. Influences of climatic conditions and weather changes on the functions of the skin.
4. Phthisis and forms of phthisis as influenced by climate and weather changes.
5. Treatment of phthisis by change of climate.
6. Pneumonia in its relations to climate and weather changes.
7. Malarial diseases in their relations to climate and weather changes.
8. Typhoid fever and the effects of climate and weather changes.
9. Diseases of the digestive system and the influence of climate and weather changes.
10. Diseases of the genito-urinary system and the influence of climate and weather changes.
11. Diseases of the nervous system and the influence of climate and weather changes.
12. Diseases of the circulatory system and the influence of climate and weather changes.
13. Yellow fever and the influence of climate and weather changes.
14. Diphtheria and the influence of climate and weather changes.
15. Other diseases which climate and weather changes appear to influence more or less.

Only two of the above lectures are now available. During the years 1893 to 1896 I prepared the 30 lectures in manuscript form. I had them about ready for publication in November, 1896, when my residence was burned and 20 of the lectures, with my books and papers of reference, were lost. I took up the work again and had almost completed the course of lectures the second time when the hurricane of September 8, 1900, swept my residence and all of its contents away. I expect, however, to rewrite these lectures at some future time.

Very few of the students before whom these lectures were delivered had studied meteorology. This is why the first half of the course of lectures was devoted to apparatus and methods and meteorology.

CLIMATE AND THOUGHT.

By Mr. E. C. Easton, *Baltimore, Md.*

[Read by title.]

Emerson says in one of his essays that there is a genius of a nation, which is not to be found in the numerical citizens, but which characterizes the society. In like manner there are characteristics in the sum total of atmospheric influences, or climate, which are not clearly discernible in its individual components, or weather. Furthermore, as changes in weather conditions have been found to affect temporarily the mental activities of individuals,[a] so may we expect to find that climatic conditions have tended to create permanent peculiarities of national character and thought. It is quite evident that nations differ greatly in this respect; and it is more than probable that these differences are not due to inherent qualities, but that they are the outcome of those external influences which are usually summed up in the term environment. To what extent the thought of man, so far as it is

[a] See Conduct and the Weather, by Prof. Edwin Grant Dexter.

a product of environment, has been affected by the factor of climate will be briefly indicated by a few extracts from various writings in which the subject has been treated.

Buckle has classed the physical agents that have most powerfully influenced the human race under four heads, namely: Climate, food, soil, and the general aspect of nature.[a] In a part of his subsequent study he arrives at the following general conclusions regarding the manner in which these agents have served to regulate thought:

> Wherever man has been able to cope successfully with their influence or where they have been found favorable to his nurture, there will the faculties of his reason assume control of the workings of his imagination; the sense of his own importance will be strengthened with each successive victory over the material manifestations of nature: the gradual growth of his powers will call into being, first, the arts, and then the sciences, and, finally, in arguing from the known to the unknown he will apply to all of the abstract problems of existence those intellectual methods which have so well served the requirements of his daily life. On the other hand, where the forces of nature, hemming him in on all sides, cooperate in opposing innumerable obstacles to his efforts, there will the feelings of terror or wonder be engendered, exciting in his mind an idea of the vague and uncontrollable, thus inflaming the imagination and bringing under its dominion the slower and more deliberate operations of the understanding.

This line of argument brings most naturally to the mind a picture of the orderly march of nature in the temperate zone, in contrast with the prodigal display of energy which is exhibited in those tropical regions where heat and moisture work their fullest effects. It is the comparison, in fact, to which Buckle afterwards resorts, selecting for his purpose Greece and India as examples of climatic contrasts, and choosing the religious beliefs of the two countries in the earlier stages of their development as affording a suitable reflex of the common thought. In addition to the favoring physical peculiarities of the former country, he says that—

> dangers of all kinds were far less numerous than in the tropical civilizations; the climate was more healthy; earthquakes were less frequent, and hurricanes less disastrous.

As a result of this the human mind was less appalled, and consequently less superstitious. It saw in itself an expression of the highest powers, and as a result established analogies between gods and men that clothed the former with all the forms, attributes, pursuits, and tastes of the latter. In India both the circumstances and results were entirely different. Not only were the fixed aspects of nature of a more imposing character, but her active energies also operated on a much grander scale, the climatic conditions producing violent and sudden tempests on the seas, swelling the rivers to impassable torrents by heavy rains, and building up on the land the tangled growth of the impenetrable jungles. All of these influences combined to create a feeling of awe and to establish in the mind of man a sense of his utter insignificance. The demonstrations of the highest powers, so far from being identified with his capabilities, were removed to the utmost degree, and as a result the religion of the people was based on a mythology of terror of the most extravagant kind. Says Buckle:

> In the dogmas of their theology, in the character of their gods, and even in the forms of their temples, we see how the sublime and threatening aspects of the external world have filled the mind of the people with those images of the grand and terrible, which they strive to reproduce in a visible form, and to which they owe the leading peculiarities of their national culture.

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[a] History of Civilization, Vol. I, Chap. II.

With the progress of history the effects of these external influences, among which climate has always had a place, have remained continually in evidence. In the temperate regions the passing of the centuries has witnessed the increasing dominion of reason over the vagaries of the imagination and the gradual emancipation of the religious beliefs from many gross forms of error. While in most of the tropical countries the intellect is still cowed by the immensity of the forces with which it is confronted, the religious beliefs taking the form of fetish worship among the lowest tribes, and relieved of strange and grotesque features in the higher civilizations only by the engrafting of foreign thought, or else through the uplifting grandeur of those great minds that appear from time to time in every nation. That even these great intellects could not wholly escape the law of environment may be seen in the spirit of fatalism which pervades the teachings of Gotama Buddha, and which finds expression in the kismet of the Mohammedan Turk.

Indeed, evidence may be adduced to prove that Christianity, in common with other great religions, has in its development encountered the potent spell of climatic influence. Renan claims that the climate of Galilee, through its influence on the minds and modes of life of the people, developed in them a nature suitable for the reception of the pure and gentle teachings of the Master. Speaking of the group that gathered on the banks of the lake of Tiberias, he writes:[a]

The beautiful climate of Galilee rendered their existence a perpetual enjoyment. One can not realize the intoxication of a life which thus glides away under the canopy of heaven; the feelings now gentle, now ardent, produced by this continual contact with nature; the dreams of those starry nights under the infinite expanse of the azure dome. It was during such a night that Jacob, with his head resting on a stone, beheld in the stars the promise of an innumerable posterity and the mysterious ladder reaching from earth to heaven by which the Elohim ascended and descended.

Not only, then, was the climate influential at the very inception of Christianity, but, if we may accept the conclusions of Kingsley, it very materially affected certain after stages of its marvelous growth. In tracing the rapid development of the monastic system he found that, while comparatively little advance was made in interior Europe—

the mountains and deserts of Egypt were full of Christian men who had fled out of a dying world in the hope of attaining everlasting life.[b]

The inducements there offered for a life of contemplation are afterwards described:

For, indeed [continues Kingsley], in no northern country can such situation be found for the monastic cell as in those great deserts which stretch from Syria to Arabia, from Arabia to Egypt, and from Egypt to Africa, properly so called. When we think of St. Antony on his mountain, we must not picture to ourselves, unless we, too, have been in the East, such a mountain as we have ever seen. We must picture to ourselves mountains blazing day after day, month after month, beneath the glorious sun and cloudless sky, in an air so invigorating that the Arabs can still support life there upon a few dates each day, and where, as has been said, "man needs there hardly to eat, drink, or sleep, for the act of breathing will give life enough;" an atmosphere of such telescopic clearness as to explain many of the strange stories which have been lately told of Antony's seemingly preternatural powers of vision. * * * The stars leap out, not twinkling, as in our damper climate here, but hanging like balls of white fire in that purple southern night, through which one seems to look beyond the stars into the infinite abyss and toward the throne of God himself.

Without at all involving a question of ultimate truths it may be said with reason that the Bible itself affords many illustrations of cli-

[a] Origins of Christianity. [b] The Hermits.

matic influences, through the apposition of meteorological and sacred events, and in the use made of the former in giving point to religious teachings. Noah saw in the deluge the pouring out of divine wrath upon a sinful generation, and knelt before the many colored arch as a symbol of God's forgiveness. Joseph interpreted Pharaoh's dream to signify that for seven long years the monsoon rains would fail to wash the mountain slopes of Abyssinia. In apostrophe and invocation the Psalmist exclaimed:

> He giveth snow like wool: He scattereth the hoar-frost like ashes: He casteth forth His ice like morsels: Who can stand before His cold? Fire and hail: snow and vapors: stormy winds fulfilling His word: Praise ye the Lord!

The winds and the rain figure in the parables of the Saviour. And as the meditations of holy men in all ages have been tinctured by their surroundings, it may be that climatic influences played some part with the dweller on the Isle of Patmos in lending color to the sublime visions of the Apocalypse.

In the writings of the poets we find an equivalent notice and a scarcely less exalted strain. Hugo has given such vivid pictures of elemental strife as to render incarnate the very spirit of the storm. Shelley's poem on the cloud appeals to every reader, not only by its beauty, but also through its accuracy of detail—furnishing, as it does, a classification of cloud forms almost identical with that worked out by scientific methods. Milton's description of the flight of Satan in search of the new-made world and of his passage through Chaos is a literary curiosity in its way; for when he says that—

> Hot, Cold, Moist, and Dry, four champions fierce,
> Strive here for mastery, and to battle bring
> Their embryon atoms—[a]

it is evident that, consciously or unconsciously, he has brought the enemy of mankind almost to the end of his journey, and extended the realms of eldest Night and Chaos into our very atmosphere; for no forecaster of the weather ever found a more perfect description of the never-ending struggle for supremacy that presents itself on every chart prepared for his study.

There is a final class of influences, more often allied to weather than to climate, deserving of notice—a class that plays upon the minor chords of our nature to produce those indefinable emotions which even the dullest of mortals have felt. They find expression in literature when Lowell exclaims, "What so rare as a day in June!" or when George Eliot speaks of the sadness of a summer evening, or, still more defiant of analysis, that spell of Indian summer, enfolding all nature in its silvery haze, which found Huckleberry Finn "lazying around, listening to the stillness."[b]

In all of its phases, then, climate affects man's mental activities; colors all of his thoughts, from his noblest aspirations to his most quiet reveries, and plays upon his soul as on a musical instrument, now rising to the highest pitch and now dying away to the faintest murmur.

These illustrations, relating to a particular feature of climatic influence, have been encountered haphazard in the pleasant pastime of desultory reading, and have but little bearing upon the practical side

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[a] Paradise Lost, Book II.

[b] Compare with Emerson's Nature, where he says: "Even the solitary places do not seem quite lonely."

of our work. Yet it would seem not altogether useless to dwell awhile upon them, for in so doing there comes to us that elevation of mind which the contemplation of any question in its far-reaching results always calls into action; and we are brought more fully to a sense of the importance of our work and of the real dignity of our profession. The first impression of our helplessness to cope with the stern laws of environment gives place to a determination to conquer. We recognize, with Buckle—

that even in those countries where the power of man has reached the highest point, the pressure of nature is still immense: but it diminishes in each succeeding generation, because our increasing knowledge enables us not so much to control nature as to foretell her movements, and thus to obviate many of the evils she would otherwise occasion.

To this increase of knowledge, the Weather Bureau within its proper domains, is devoting its best energies, and the reward due to earnest and systematic effort will not be withheld.

SECTION 3.—FORECASTS AND FORECASTING.

ADDRESS OF THE CHAIRMAN, PROF. E. B. GARRIOTT.

The subject of the third session, "Forecasts and forecasting," is undoubtedly the most important one that can be considered by this convention. In successive annual reports the Chief of the Weather Bureau has announced that the forecasting of severe storms, tropical hurricanes, cold waves, and frosts is the first and most important duty of the Weather Bureau, and that no effort has been spared to strengthen and improve the forecast service wherever and whenever opportunity presented itself. The administrative officers of the Department and of the Bureau recognize that this is the work for which the national weather service was established, and that this is the work for which it is maintained. They recognize that, in relation to this—the first and most important duty of the Weather Bureau—all other kinds and classes of work must necessarily be secondary and subsidiary, and that the value of all other kinds of Weather Bureau work, whether conducted with a view to the improvement of our instrumental equipment or in theoretical and practical investigations and studies of the phenomenon of the atmosphere, is measured by the extent to which they improve or promise to improve the forecasts.

The benefits derived from the forecasts and warnings represent a declared dividend on an investment by the American people of more than $1,000,000 a year. That the investment is a profitable one can not be doubted, and it is safe to say that there has not been a year in the last ten years during which the benefits derived from the warnings have not equaled or exceeded in value many times the annual appropriation, and in several instances the value of property saved by warnings issued in connection with a single storm has equaled the amount appropriated for the maintenance of the service for a number of years. And in addition to the property thus saved the loss of hundreds of human lives has been averted by the storm warnings.

Of scarcely less importance have been the warnings of cold waves and frost. The value of these warnings to tobacco, cotton, fruit, and truck growers has been conspicuous, and it is also recognized on the stock ranges of the west, the northwest, and the southwest, and by merchants and handlers of perishable goods throughout the United

States. The value of the warnings as a means of saving, outright, crops of a fixed value is shown in the citrus fruit districts of the southern tier of States; and in a number of single instances the money value of oranges and orange trees saved in Florida alone by the warnings has aggregated hundreds of thousands of dollars. I think our representatives from Florida, Mr. Mitchell, and from the west Gulf States, Dr. Cline, can testify with regard to the value of the cold-wave and frost warnings to the fruit and trucking interests of the Gulf districts, and Professor McAdie can testify with regard to the value of frost and rain warnings to the fruit growers of California. Numerous instances can be cited in which the value of berries and truck products saved by the cold-wave and frost warnings represent an enormous return on the annual expenditure. In fact, the benefits of the storm, cold-wave, and frost warnings are universally acknowledged by those who have by experience learned their value. And a consideration of the forecasts and warnings forms a part of the business calculations of every up-to-date merchant, vessel owner, vessel master, and agriculturist of the United States, and they are of interest and value to every American citizen.

At no time in the history of the Weather Bureau has the attention been paid that is now being paid to forecasting. With but few exceptions, daily local forecasts are made by officials in charge of Weather Bureau stations throughout the United States. These forecasts are carefully verified, with a view to determining the relative skill of forecasters, and marked skill in forecasting and in discovering aids to forecasting has been announced as the price of promotion.

There appears to be a general misunderstanding as to the manner in which forecasts are verified. In the topics for discussion we have the questions whether forecasts should be verified by a maximum and minimum temperature and whether slight changes in temperature shall be forecast and verified. Verifications made for a station—New York City, for instance—are not compared with verifications made for stations in other parts of the country; they are compared with forecasts made for New York City. You will, perhaps, be surprised to know that there are seven or eight people making forecasts for every station of the Weather Bureau each day. All national forecast officials east of the Rocky Mountains, including those at the central office, make each morning a practice forecast for the entire United States. Each local forecast official prepares each morning a forecast for his own and for an additional or "outer" station. Verifications are made for rain and temperature changes alone; fair-weather forecasts are not verified. In a forecast of rain made, say, this morning (Wednesday) for to-night and Thursday, if no rain falls, two failures are charged against the forecaster. If rain is shown at the morning observation, or at the evening observation, of Thursday, the verification shows one failure and one success. If rain shows at both the morning and evening observations of Thursday, the forecaster is credited with two successes. If rain falls during both periods and no forecast of rain has been made, two failures are noted, and the same process is employed in verifying temperature forecasts. When no temperature is forecast, there is no verification, unless a change to equal or exceed the stationary limit occurs, when a failure is charged. When temperature is forecast, the change must equal or exceed the limit for the season, which during the summer months is six degrees. The only exception to these rules is found in connection with the occurrence of thunderstorms. A thunderstorm, when reported at a station, will verify a rain forecast

or a thunderstorm forecast for that station, even if no precipitation is recorded. The only dividend you have in determining verifications of forecasts is your successes. The matter of verifying by maximum and minimum temperatures instead of by the morning and evening temperatures is one which will be open to discussion. This was the method employed a few years ago at the central office. The change was made on the request of the forecast officials.

As the matter of distributing forecasts comes under another session, we will now proceed with the regular programme.

THE RELATION BETWEEN GENERAL AND LOCAL FORECASTS.

By Mr. Ferdinand J. Walz, *Chicago, Ill.*

As a prelude to a discussion of the relation between the general and local forecasts, it may be well to consider for a moment the question of who may make official forecasts.

Weather Bureau Instructions Nos. 7 and 19, 1896, and No. 136, 1899, give full and final information upon this subject. Under the provisions and limitations of these instructions all section directors and local forecast officials, by reason of their rank, and observers that have been given special authority therefor are permitted to make and issue official forecasts for the station (and vicinity) at which they are serving. These, and only these, are authorized to make local forecasts. The general forecasts are made by officials under special assignment. This presupposes, then, that only those who have sufficient knowledge, training, and experience in forecasting and atmospheric physics have the authority to make official forecasts. And the experience and training can be efficiently acquired only in the active service of the Weather Bureau. The general forecasters are for the most part postgraduate local forecasters and have been selected on account of their superior ability in the local-forecast work and their fitness, through study, research, and long experience, for duty in the larger field.

In a paper to be read before an audience of Weather Bureau officials, it would be superfluous to enter into any details as to what information relative to the weather elements is entered upon a weather map, or what constitutes a weather map, either in the published form furnished to the public or in the special pencil charts used in forecasting. Nor is it necessary for me to enumerate the specialties which attract our attention as experts in the interpretation of the weather charts or to elaborate upon the general rules and laws which govern us in forecasting coming weather events from them. These are our tools of trade with which we presumably are all familiar.

The original weather maps that contain the entries of barometer, temperature, wind direction and velocity, rainfall, and state of the weather, together with the drawn isobars and isotherms and the defined areas of "high" and "low," and which depicts gradients in pressure and gradients in temperature, is the same for the general forecaster as it is for the local forecaster, except that the chart for the former may contain entries from more stations and cover a greater extent of territory. The general forecaster and the local forecaster alike approach these charts along the same pathway of reasoning and base their deductions upon the same controlling phenomena—namely, the areas of high and of low pressure, their gradients and char-

acteristics. The teachings and experience of each tells him that the weather and weather changes experienced from day to day over the territory covered by these charts depend most largely upon these areas, their relative positions, their characteristics, their frequency, and their paths and rate of movement. Each studies and carefully notes the developments and the movements in the atmosphere in the preceding twelve and twenty-four hours as evidenced by these areas, and from the knowledge thus obtained draws his conclusions as to the sequence of weather that will probably follow in the next twelve to thirty-six hours. Up to this point the course of operations and the psychological pathway of the general forecaster and the local forecaster are practically the same. But here begins a parting of the ways.

The general forecaster is interested in and issues not only the forecasts of weather and temperature for large sections of the country, but he is also responsible for the issuing of timely warnings of storms, high winds, frosts, cold waves, heavy snows, and, in fact, of all weather events that are likely to be injurious to agriculture and commerce or that might be destructive to lives and property in his district. He must then weigh well nature's forces as marshaled on the meteorological maps before him and mentally shift these forces to a new field of action for the night and the morrow. He must predetermine not only the new battlefield, but must make an empirical estimate of the results of the conflict in each portion of it. He determines in his mind and to his satisfaction where these cyclonic and anticyclonic areas will be twelve and twenty-four hours hence. What will be their probable path and rate of movement and what their character then—will they gain or lose in energy? Will they increase or diminish in cloud and rain areas? And what portion of his section will be affected? Will the wind shift or change its velocity; and if so, how and when and where? Having satisfied himself as to these, he issues his forecasts accordingly. Hence, his forecasts are, or should be, an expression of his judgment upon these important points, and should be easily read as such by anyone experienced in forecasting or familiar with weather maps. One of our most distinguished forecasters says that he considers a forecast a good one if the line of reasoning pursued by the forecaster in reaching his conclusions is plainly evidenced in the forecast (provided, of course, the reasoning was sound), whether the forecast in this particular instance is verified or not. He considered it a better forecast, even if not verified, than one not showing any valid basis in charted facts, though verified. The latter was pure guess, and forecasts showing valid reasoning would win, in the long run, against guess forecasts at least four out of five times. The local forecaster, then, when he receives the State forecast, has the opinion of the general forecaster upon these all-important factors: probable storm movement and probable storm development. This manifestly should be a decided additional aid to him in determining upon his local prediction.

It is for this reason that local forecasters are prohibited, in Instructions No. 42, 1896, from issuing their forecast (in the absence of special authority to the contrary) until after the receipt of the State forecasts. It is far from the intention of the instructions, however, to restrict the local forecaster or to compel him to conform his forecasts for his vicinity to the State forecast, but, on the contrary, he is at liberty to not only amplify the State forecast, but to express his own opinion in his forecasts, as far as his judgment of the condition warrants, even to differing entirely with the State forecasts.

ADVANTAGES OF THE NATIONAL FORECASTER.

1. (*a*) Fuller reports. (*b*) Telegraphic reports from a greater number of stations and covering a much larger extent of territory.

2. (*a*) Auxiliary charts showing pressure changes in past twelve and in past twenty-four hours and departure from normal. (*b*) Auxiliary charts showing temperature changes in past twelve and in past twenty-four hours, with departures from normal.

3. On account of his great responsibilities, extending over a large area of country, and to the marine interests of the Great Lakes and the Gulf and the Atlantic and the Pacific coasts, the general forecaster must at all times keep in close touch with the entire meteorological situation liable to affect his district. For this purpose he can call for special observations. Also, local observers send him special observations when marked local indications of approaching changes appear or upon the occurrence of any violent meteorological event.

4. Training, study, and experience.

5. General forecasters for the most part devote undivided attention when on forecast duty to forecast work, and when off forecast duty to study of weather data, maps, storm types, etc., and engage in such research and studies as tend to increase knowledge of weather habits and promote weather forecasting.

6. General forecasters make a forecast for verification every day, both when on and off official-forecast duty, for every part of the United States. This keeps them in continuous training and practice and familiarizes them with the general run of conditions for all sections.

DISADVANTAGES OF THE GENERAL FORECASTER.

1. Short time at his disposal and consequent rapidity with which he must make his deductions and reach his conclusions in issuing his forecasts. At the Chicago forecast center, where are issued daily forecasts of weather, temperature, and winds, and special warnings of storms, cold waves, etc., for the Upper lakes and the twelve States of Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Kansas, Nebraska, South Dakota, North Dakota, and Montana, the total time at the disposal of the forecaster for this purpose is about thirty minutes. It is impossible in this short time to do more than express in any but the most general terms the character of the expected weather and the changes for each State or portion of a State.

2. The State forecasts having to be telegraphed to a great many points, must be brief and concise; and that no delay may occur in transmission and receipt, they must be promptly delivered in regular succession to the telegraph operators.

3. Vocabulary for expressing forecasts is limited. Wording of forecasts must conform as far as possible to the words contained in the logotype duplicating outfit.

The local forecaster is concerned with but a single locality and can concentrate his attention, faculties, and facilities in his deductions upon this limited area. He studies the map only in respect to his own location and deliberates upon the dominant features that seem likely to affect his immediate vicinity. He is aided in his conclusion by a personal knowledge of his surroundings, the local topography of the country. If he be a careful observer, he is cognizant of the local aspect of the sky and the changes occurring or which have recently occurred. He makes his forecast two hours or more later than the

observation upon which the general forecaster depends and can take advantage of the changes occurring in the interim. The barograph trace sheet often gives a valuable clue. Then he is familiar with local signs and the sequence in which weather changes in his locality occur. All these he has time to consider in arriving at the conclusions expressed in his forecast.

SUGGESTIONS FOR STUDY FOR LOCAL FORECASTERS.

Prevailing wind for fair weather.

Prevailing wind for foul weather.

Local shift of the wind, and the sequence of weather following; the prevailing direction of wind during the twenty-four hours immediately preceding the advance of a storm.

The shift of the wind with the approach of storms, especially for the winter and spring months.

Formulate local rules in regard to temperature changes which will guide in determining the amount of the expected change and the probable limits that will be registered in important thermal events.

The possibilities of frost and the air temperatures at the local and neighboring stations with which light and injurious frosts will occur.

Professor Moore, in his Meteorological Almanac for 1901 (page 39), gives a number of local rules evolved by him while at Milwaukee for the State of Wisconsin. Rules similar to these, or along this line, should be worked out by all local forecasters, and when accomplished should be collected and published as a bulletin of the Weather Bureau.

The experience of the writer at stations where he has made local forecasts has been that a change in temperature at some selected remote station, or a combination of two or three such stations, very often proved an index to the probable change at the local station and gave information fairly reliable upon which to base a prediction (accurate to within a degree or two) of the maximum or minimum temperature—more especially applicable to the latter—likely to be recorded. At Baltimore it was found that the change at Pittsburg, Parkersburg, or Columbus, or a combination of the three, when studied in connection with the departure from the normal at these stations and at Baltimore, very often enabled one to predetermine quite closely the limits of temperature that would occur at Baltimore within the succeeding twenty-four to thirty-six hours. Of course, the probable movement of the "low" or "high" pressure areas, as the case might be, attending marked changes in temperature had to be carefully considered, as the future path of these areas has great influence in modifying the change in temperature at Baltimore subsequent to that already registered at the stations named. In a similar manner a study of the thermal situation at Huron, Bismarck, and Moorhead was found to give a reliable clue to the probable temperatures and the changes that would occur at Davenport during the succeeding twenty-four to thirty-six hours.

At Baltimore, in connection with a detailed study of cyclonic and anticyclonic weather conditions in its bearing upon the climate of Maryland, tables were prepared and published[a] showing the percentage of times rain followed in twelve, twenty-four, thirty-six, and forty-eight hours, respectively, of the time Baltimore was located in every part of a cyclonic or an anticyclonic area. Cyclonic areas having origin in the northwest or over the western plateau region differ considerably in characteristics from those which originate in the South-

[a] Maryland Weather Service, Vol. I, 1899.

west or in the Gulf region; hence the two were treated separately in the tables. These tables were prepared for the different seasons of the year. The application of this study in local forecasting is best shown by an example or two. If on a weather map Baltimore be found located in the NNE. octant and 700 to 1,000 miles from the center of a cyclonic area which had its origin in the Gulf region—that is, a storm is centered over Florida or the eastern Gulf—and the time is December, January, or February, the tables show that in the past such a position occurred 17 times in five years, and was followed 53 per cent by rain beginning within twelve hours, 35 per cent by rain beginning in twenty-four hours, 0 per cent by rain beginning in thirty-six hours. If the storm center were in the same direction, but from 400 to 700 miles distant—that is, in Georgia or South Carolina—the percentages of 15 similar occurrences in the past were 47, 13, 0, respectively; and if from 100 to 400 miles distant, or in Virginia or South Carolina, the percentages of 8 occurrences were 88, 0, 0, respectively.

Again, if Baltimore be found in the ENE. octant of a storm of like origin and the same time of year and at a distance of 700 to 1,000 miles, or the storm centered in Missouri or the lower Mississippi valley, the percentages of 33 occurrences are 54 per cent in twelve hours, 21 per cent in twenty-four hours, and 6 per cent in thirty-six hours; while if the storm were 400 to 700 miles away—that is, centered in the Ohio Valley or Tennessee—the percentages of 20 occurrences are 100, 0, 0, respectively.

Baltimore, located in the WSW. portion of the anticyclonic area and 100 to 400 miles from the center, November to March, inclusive, is shown by the tables in 10 occurrences to have been followed 70 per cent by rain beginning in twenty-four hours and 40 per cent in 48 hours, but if from 400 to 700 miles distant the percentages fall to 44 in twenty-four hours and 11 in forty-eight hours. On the other hand, if from 700 to 1,000 miles distant, the percentage rapidly increases to 100 for rain beginning in twenty-four hours. These are given only as illustrations suggestive of the possibilities of lines of study the local forecaster may pursue and apply in his forecast work.

The local forecaster, if he is familiar with the local influence of his surroundings and has acquainted himself with local signs and has formulated from his own experience and from recorded data local laws, then, aided by the advance State forecast, should make a higher average in his percentage of verification than the State forecasts applied to his station.

The general forecaster depends entirely upon the charted conditions and charted changes before him, his experience and his knowledge of storm development, characteristics and movement and the general laws of air physics. It is an easy matter to find a map that equally experienced and trustworthy forecasters will differ in judgment upon, and maps appear, all too frequently for the comfort and reputation of the forecaster, from which it is more than difficult to make any accurate and uniform deductions.

Equipped, then, along the lines before suggested, the local forecaster should be well qualified to stand sentinel for his vicinity, and should not hesitate to take issue with the State forecasts, when, in his opinion, the local conditions justify it. He is remiss in his duty to the people he is serving and to the Bureau if he fails to do so. If he differs to advantage, it shows upon his record, and his official reputation as a reliable forecaster expands. On the other hand, if he differs rarely, or never, his reputation as a forecaster suffers, for he is practically

making no forecasts upon his own responsibility. But he can not differ to advantage unless he masters the local situation.

Weather Bureau instructions require that all official forecasts be prepared with the purpose in view of thoroughly subserving the public interest, and represent as explicitly as possible the judgment of the forecast official respecting the conditions expected, and they should be so worded.

Local forecasters are especially encouraged to amplify their own and the State forecasts with particular regard to local interests and the occurrence of local events, and to express themselves in such terms and so completely as to give to the public the largest measure of benefit to be derived from the Weather Bureau.

VERIFICATION OF FORECASTS.

In the verification of forecasts at the Central Office and at the forecast centers the State forecasts are taken as a standard, and all local forecasts are verified and compared with them; hence it would not be amiss for me in this paper, which deals with the relation between the two, to enter into somewhat detailed explanation of the methods and forms employed in obtaining verifications, especially as I am not sure that many of those authorized to issue local forecasts are familiar with either the methods or the forms.

The system used at the Chicago center was devised by Prof. Henry J. Cox, and differs considerably from that used at the Central Office, making it essential that the two systems be explained separately.

Central office system of verification.—The State and local forecasts are verified at the central office by stations, and only the stations which telegraph daily reports are used. The forms (or "verification slips," as they are officially designated) employed have headings and subheadings as follows:

Verification slip.

Date of forecasts, —— ——.

Stations.	Precipitation.				Temperature.			
	Success.		Failure and not forecast.		Success.		Failure and not forecast.	
	State.	Local.	State.	Local.	State.	Local.	State.	Local.
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One of these slips is required for each day. Forecasts are verified, that is, entries are made, only with reference to .01 of an inch of rainfall and temperature changes which equal or exceed the stationary limit, except that a thunderstorm forecast or a forecast of rain is verified as a success at a station where thunder is reported, even when no rain occurs.

The verification entries are made on a basis of 10, or rather on a basis of 5, for each twelve-hour period. For example, a forecast of rain for both periods would be verified if rain occurred in both periods as 10 success, while if rain occurred only in one period and not in the other the entries would be 5 success, 5 failure. A forecast of rain for one period and fair for the other would be verified if the rain occurred in the proper period as 1 success, while if rain occurred in the period for which fair is forecast the entry would be 2 failures.

I would here especially call your attention strongly to the fact that a forecast of fair weather counts nothing, even if the forecast proves correct, while, on the other hand, it counts 5 failure for each period it is in error. In other words, a forecast of fair stands the forecaster

nothing to win and 5 for each period to lose, while a forecast of rain stands 5 to win and 5 to lose.

In the verification of temperature the stationary limit is 6° from June to September, inclusive; 8° for April, May, October, and November, and 10° for December to March, inclusive. This means that all changes in temperature in twenty-four hours, based upon 8 a. m. to 8 a. m. readings and 8 p. m. to 8 p. m. readings, equaling or exceeding these amounts, occurring in these months, must be predicted, or else the forecast is charged a failure. A forecast for colder or warmer "to-night" is verified from the twenty-four hour changes on the a. m. map following. A forecast colder or warmer for the second period is verified from the twenty-four hour changes on the p. m. map of the succeeding day.

A forecast of warmer, colder, slightly warmer, slightly colder, slowly rising or slowly falling temperature, not so warm, not so cold, etc., for both periods would verify 10 success, provided the 8 a. m. and 8 p. m. maps of next day each showed a temperature change equal to or exceeding the stationary limit, while if only one showed such a change the entries would be 5 failure, 5 success; if neither showed such a change, 10 failure. A forecast of stationary temperature, slight change in temperature, or no forecast of temperature bring no entries if temperature changes less than the stationary limit occur, but 5 failure is marked against each period in which a temperature change equal to or exceeding the stationary limit is reported. As in the case of fair weather prediction, a forecast of stationary temperature stands the forecaster nothing to win and 5 for each period to lose.

A forecast of warmer followed by stationary temperature could be verified as 5 success, 5 failure, or 10 failure.

In the Chicago system of verification, explained later, a prediction of warmer or colder which is followed by a change in temperature in the opposite direction equal to or exceeding the verifying limits would be counted as 10 failure (on a like basis) for each period in error; that is, 5 failure for the predicted change which did not come, and 5 failure for the change which came but was not foretold.

The percentage of verification is obtained by dividing the total of the successes multiplied by 100 by the total successes plus total failures (or $\frac{S \times 100}{S+F}$), the quotient being the per cent of successes.

Each slip, when completed, shows the average percentage of verification for one day of the forecasts made by the general forecaster, and the average percentage of all the local forecasts made by the local forecasters for the same stations.

Chicago system of verification of forecasts.—A form is employed with headings and subheadings as follows:

	State forecast (made at Chicago, Ill.).								Local forecast (Milwaukee, Wis.).							
	Forecast.				No forecast.				Forecast.				No forecast.			
	Rain.		Temperature.		Rain.		Temperature.		Rain.		Temperature.		Rain.		Temperature.	
	1st.	2d.	1st.	2d.	1st.	2d.	1st.	2d.	1st.	2d.	1st.	2d.	1st.	2d.	1st.	2d.
1																
2																
3																
4																
5																
6																

One form is required for each station for each month. As at the central office, predictions of fair weather and of stationary temperature are not considered in the verification. Entries of successes are made in red, and entries of failures in blue. This is best explained by examples. Under the heading "Forecast rain," the letter R is entered in red for the proper period when rain is forecast and 0.01 of an inch or more of precipitation occurs in that period. A blue R is entered when rain is forecast and this amount does not fall.

Also under this heading the thunderstorm (☈) symbol in red is entered when the forecast is for thunderstorms, showers or rain, and a thunderstorm is reported from the station but no rain, or only a trace, accompanies it. However, a blue (☈) symbol is not entered when thunderstorms are predicted and rain to the amount of 0.01 of an inch or more falls but no thunder is reported. In other words, a forecast of thunderstorms, rain, or showers is verified as a success either by the occurrence of a dry thunderstorm or a fall of 0.01 of an inch or more of rain. Under the heading "No forecast, rain," a blue R is entered for the proper period when the forecast is fair weather and 0.01 of an inch or more of rain falls in that period.

Under the heading "Forecast, temperature," a red C or a red W is entered under the proper period when colder or warmer, as the case may be, is forecast and a temperature change equaling or exceeding the stationary limit occurs, and a blue C or W when the temperature changes are less than that amount.

Under the heading "No forecast, temperature," is entered a blue C or W when a change in the temperature equaling or exceeding the stationary limit occurs which was not forecast.

As previously stated, in case a prediction of colder or warmer is followed by a change equaling or exceeding the stationary limit, but in the wrong direction, a double failure is registered; that is, a blue C (if the forecast was colder) is entered under "Forecasts, temperature," and a blue W under "No forecasts, temperature."

The percentage of verification is obtained, first, by summing up the red entries for the month under rain, and then the blue entries under both rain forecast and rain not forecast. Add all together and divide the sum of the reds multiplied by 100 by the total of all the reds and blues. The quotient thus obtained will be the percentage of successful weather forecasts. Second, divide in same manner the sum of the red entries under temperature multiplied by 100 by the total of the reds and blues, and the quotient will be the percentage of successful temperature forecasts. The percentage for both elements is the mean of the two.

It should here be stated that the Central Office verifications only compose the official record of the forecaster. The Chicago verifications are for comparison and for the information of the official in charge of the district.

The Chicago system of verification has especial merit in that it not only gives a comparable record of the relative accuracy of the general and local forecasts, but is an excellent medium of suggestions tending to a betterment of the forecasts. The character of the forecasts, especially the failures, are clearly shown, and a study of failures is the best means of improvement. Failures of a positive character—that is, forecasts of weather which does not come—are separated from failures of a negative character, or weather happenings not predicted, and thus the relative values of the two are clearly perceived. By close attention to these verifications one soon discovers whether his

failures are due to too much or too little prediction of rain, and an investigation of the maps for the causes is suggested. Also, like suggestions are brought out when it is seen that the general and the local forecasts often differ to the advantage of one or the other.

We have all experienced periods in our attempts at weather forecasting when it seemed that the old adage, "All signs fail in dry weather," was never truer, and when, under what would be in ordinary times almost sure rain conditions, we predict rain, the rain storms persistently refuse to materialize. It is then that the blue R's under "Forecast, rain" pile up on the verification sheet. And again we have experienced periods of the opposite kind, when every little "low" that appeared anywhere on the map gave copious and unexpected rains, and even "highs" would give downpours in the most unexpected places: then the blue R's pile up under "Rain, no forecast." Such periods are plainly manifest on the verification sheets, and suggest research for the causes.

Then, too, a study of these sheets proves a sort of open sesame to character reading, and we are, in a measure, able to gauge the prophetic individuality of the forecaster; that is, his predisposition to predict rain or fair weather when conditions on the charts run uncertain. To such a degree is this true that at the Chicago station we are in the habit of classifying certain forecasters as rain men and others as dry-weather men.

Other possibilities of these forecast-verification sheets are the determining whether failures occur more often in the forecast for the first or in the forecast for the second period; whether forecasts are more accurate for night or for day, and where the forecast of longer range can be made with greater accuracy.

I believe from the foregoing that I am justified in suggesting the adoption, if they have not already done so, of some such system of verification as this by all engaged in official forecasting, and a systematic study of the results obtained.

In conclusion, I would call the attention of all local forecasters to the importance of sending cards or maps to the forecast centers in which they are located when their forecast differs from the State forecast.

Instructions No. 120, 1900, directs that all local forecasts be entered daily upon "Form 1069—Met'l" and sent by mail, attached to the local map or bulletin of corresponding date, to the Central Office whether they differ from the State forecasts or not. This does not revoke the instructions contained in circular letter, forecast division, November 6, 1899, which directs that in case a local forecast is made which differs from the State forecast a duplicate copy of "Form 1069—Met'l," containing the differing forecast properly underscored, be mailed to the station of the forecast official in whose district the local office is located.

DISCUSSION.

Mr. EDWARD H. BOWIE (Galveston). After hearing the paper by Mr. Walz it would seem that a discussion is hardly necessary, as he has treated all phases thereof in a manner that leaves little to be said. However, because of the importance of the subject, it may not be amiss to lend additional weight to the force of his instructive and valuable remarks.

That the weather conditions over an area of any considerable extent are comparatively local, anyone versed in the science of meteorology is forced to admit.

How difficult and with a much less degree of certainty must it be then to describe the probable weather conditions for the next twenty-four to forty-eight hours for any one place; and even more difficult must it be to attempt to describe the probable conditions for an area such as any one of our large States comprises. That this is recognized by the successive chiefs of the Weather Bureau is shown by the growing latitude given the forecaster, especially the local forecaster, in his efforts to describe from day to day the sequence of weather changes that will occur for any region or locality within the coming twenty-four to forty-eight hours.

The general forecaster has not the time to attempt to describe in detail the probable weather for the period forecast for, and hence has to limit his forecast vocabulary to such expressions as will best describe the general weather conditions in a few words, such as fair, rain, showers, clearing, threatening, colder, warmer, etc., as the expected conditions may call for, and, necessarily, that which will apply to one portion of the State will not be appropriate at all for another portion. It is on the local forecaster, therefore, that the duty devolves to make in detail a forecast of the expected conditions for his limited territory. This is the primary object of the authority bestowed to make local forecasts, and if one fails to use this authority to make such forecasts, provided he is competent to do so, the purpose for which the authority is granted is not attained. Local forecasting is not that part of the State forecast which applies to the vicinity in which the local forecaster's station is located. A child could do this. When authority to make local forecasts is requested the Central Office is led to believe that the applicant has made a study of the local conditions peculiar to his vicinity, and considers himself, by reason of this particular study, competent to forecast. It is in this field that the local forecaster can be of the greatest value, and not in habitually placing his skill against that of the general forecaster in cases when the conditions are clear and definite, and when, owing to the larger number of reports and the various subsidiary charts at the disposal of the district forecaster, he has a great advantage over the local forecaster. It is when cases of extreme doubt arise that the local forecaster is able to supplement the information given in the State forecast and make a prediction of a greater degree of accuracy. These conditions are especially frequent during the summer months, when the types are flat and local causes are potential in causing weather changes.

Mr. Walz has indicated a number of lines along which studies of peculiar local conditions might be followed, and it will be well for each one of us to follow out, if we have not already done so, similar lines of study.

Authority to make local forecasts for a station carries with it a sharing of responsibility with the general forecaster for failures in forecasting and equal credit for success. This responsibility rests on the local forecaster whether or not his work is that of a careful forecaster, one who studies the local conditions and forecasts accordingly, or that of a passive forecaster, one who never differs the local forecast from the State forecast, no matter what the local conditions indicate—or again that of one who habitually differs, in some instances, apparently for no other reason than simply to differ. It is this last kind of work that is the most pernicious form of local forecasting, and such forecasters should have their authority to forecast curtailed or, possibly better, taken from them.

The matter contained in the local forecast should give in detail a

description of the probable conditions in words that will convey a definite meaning to the public. During the season of freezing temperature a forecast of the probable minimum temperature for the following night is of great value to shippers of perishable goods, dealers in fruits, brewers, and many others. This forecasting is comparatively easy, and it is the speaker's opinion that during such times the local forecasting of the minimum temperature for the following night should be made obligatory. At Dubuque, Iowa, where the speaker was last stationed, the number of requests during the winter months for this information exceeded that for all other kinds of information. The forecasting of winds at interior stations should receive attention, as by such the public will be helped greatly in understanding the course of reasoning followed in making the forecast.

SHOULD THE VERIFYING CHANGE OF TEMPERATURE BE SMALLER, AND SHOULD NOT THE TERMS "SLIGHTLY WARMER" OR "SLIGHTLY COOLER" BE CREDITED?

By Prof. H. J. Cox, *Chicago, Ill.*

Several years ago, in discussing forecasting and verifications with a prominent official of this Bureau, he made the following statement:

> Good forecasts will invariably attain a high percentage of verification, no matter what rules are used.

Only a short time ago I heard the same official make another statement which bore on the same subject. He said:

> After men have qualified as general and local forecasters and shown that they are able to make good predictions, their forecasts should be exempt from technical verification and they should be encouraged to make the best possible forecasts in the interests of the public, and absolutely without regard to verification.

These two statements deserve thorough consideration at our hands, and may serve as a basis for this discussion.

I have seen many instances of forecasts, excellent from the point of view of the public, obtaining no verification and even a minus quantity. The present rules of verification are probably as good and even better than any that have ever been used previously by the Weather Bureau, yet it seems to me that they are very faulty and should be changed in many important particulars or else rules abolished entirely. Weather predictions are made for the benefit of the public, in the interests of the farmer, the shipper and handler of perishable goods, the iceman, the ice-cream man, and the like. Yet the official, in issuing his forecasts from day to day, often finds himself actually hampered and restricted by the rules of the Bureau. If threatening rain is approaching he must determine whether it will reach a certain point at a certain stated time, either 8 a. m. or 8 p. m.; if before 8 a. m. it is night; if after 8 a. m. it is the morrow; yet this 8 a. m. Washington time is 7 at Chicago, 6 at Denver, and 5 at San Francisco. This time marks the ending of the night in every case, as far as the Weather Bureau verification is concerned; but certainly people the country over have a different idea of night, and do not believe that it begins and ends according to our standard, but that it begins at dark and ends at dawn; even some think that the night forecast ends with midnight. A forecast of rain for the following night is verified, provided .01 of an inch falls between the following 8 p. m. and 8 a. m.; it is of course verified if the rain falls just before

the following 8 a. m.. Up to that time it is considered night by us, but certainly not by the public. A man may forecast snow flurries and they may occur at frequent intervals, giving him apparent ample verification; yet at the following observation a trace only may be recorded, oftentimes due to rapid evaporation or melting, and another example is offered of a good forecast with a bad verification. According to the present rules of the Bureau, the forecaster who fails to predict rain loses no more if 1 inch falls than if 0.01 of an inch is recorded, and this 0.01 of an inch may in exceptional cases be due to the large personal error of the local observer. Had the forecast been for fair weather, he might not have seen so much. If a forecaster should be so unfortunate as to make a forecast of rain for the wrong period—that is, fair weather for the first and rain for the second, while rain actually occurred in the first period and fair weather in the second—it would be far better for his verification not to predict rain at all, although the forecast might be a good one and be apparently verified. When the farmers are crying and praying for rain, it matters little to them in what period the rain falls, so long as they get it, and the forecast which they consider successful should have a value in the verification.

The forecasts of temperature are verified by the twenty-four hour changes shown on the temperature maps at 8 a. m. and 8 p. m. These verifications and failures are often simply accidental, and do not indicate the proper value of the forecast. In the spring and the summer afternoons thunderstorms create havoc with temperature verifications, and lake and ocean winds are often most important factors in cooling the air toward evening after a warm and distressing day. The public invariably consider the maximum and minimum temperatures in their estimates of warm and cool days. Frequently, although the maximum temperature shows a much higher reading on a certain day than on the day previous, yet the 8 p. m. temperature, through some accidental disturbance or shift of the wind, may show a lower reading than that which prevailed twenty-four hours previous. During the recent hot wave a maximum temperature of 104°—breaking all records—was recorded at St. Paul on July 24. On the previous day a maximum of 100° was reached. On July 23, the first day, the forecast was for "continued warm" over the second day, but a loss was registered against the forecaster because the 8 p. m. reading on the first day was 12° higher than on the second, although the maximum on the second day was 4° higher than on the first. Instances of this kind might be enumerated without number. Again, a forecast of temperature for "to-night," or the first period, is not verified by the temperature prevailing during the night, but by the change noted at 8 o'clock the next morning. In other words, it is simply a prediction of the probable temperature at that hour.

Instructions No. 40 of 1899, provide in regard to temperature verification, that changes equaling or exceeding the stationary limit, which is 6° from June to September, inclusive; 8° from April to November, inclusive; and 10° from December to March, inclusive, will be charged if not forecast; and these limiting changes must be reached in order to obtain verification of the temperature forecasts. I do not know why the stationary limit varies during different seasons of the year unless it is because the changes are generally greater during the winter than in summer. The forecasting of changes in summer is important, because during that season personal comfort and even health are affected by extreme hot weather, and the condition

of certain perishable goods varies decidedly, often requiring much attention in order to prevent decay. During the spring and fall in the northern States temperature forecasts are generally of comparatively little importance, but in the winter they assume their greatest value, as a slight fall in the temperature often results in the freezing of goods and in their absolute destruction. Much may be said both for and against the forecasting of slight changes in temperature. Occasionally warm waves gradually develop during the summer time with the rise in temperature from 2° to 6° each day. A few instances have been found where the daily temperature rise over the greater portion of the country was slight and not sufficient to verify forecasts of warmer weather under the present rules, although at the end of three or four days extreme hot weather had overspread the country. While the forecasting of the gradual rise in temperature under such conditions is important, forecasts of cooler weather, after the hot wave has once developed, should be made with the greatest care. I believe it important that under these conditions cooler weather should not be forecast unless the hot wave is about to break, and that predictions of slightly cooler should not, under any circumstances, be made unless it is expected that the temperature will gradually fall from day to day, and ultimately bring on cool weather. During extreme hot weather slight changes are seldom felt. Often, in fact, although the temperature may fall 4° or 6°, personal discomfort intensifies because usually the relative humidity rises daily, thereby increasing the sensible temperature. Again, when humanity is sweltering during a protracted heated spell the mere mention of cooler weather, even though slight, is made much of by the press and public, and disappointment is evident should the temperature not be materially lowered. An unsuccessful forecast of cooler weather is then likely to invite severe criticism. Far better is it that the hot wave should break sooner than anticipated than that false hopes be held out during such a period. People are satisfied with the coming of cooler weather, even though it had not been forecast, but should the break in the hot wave fail to come, forecasts of lower temperature only add to their exasperation and distress.

Predictions of temperature changes are undoubtedly of greater importance in nearly every section of the country during the winter than in any other season of the year. The successful shipment of perishable goods absolutely depends upon the temperature conditions, and it is generally important to know within a few degrees what the minimum is likely to be over a certain area—whether to ship in ordinary cars with no protection, or to use packing or refrigerator cars, or not to ship at all. A cold wave seldom approaches gradually, but usually comes with a rush. Yet after the first fall frequently the temperature drops lower and lower a few degrees from day to day. Often, moreover, the recovery from a cold spell is gradual. It is important to keep the public well informed as to these coming slight changes, as much depends upon them. The successful forecasting of the ensuing temperature during twenty-four hours in the winter season is easy as compared with other seasons, but unless slight changes are anticipated the public is deprived of information which should be in its hands. Several years ago my predecessor in Chicago, Professor Garriott, inaugurated a plan to include in the winter season in his local forecast an estimate of the minimum temperature during the following night. This information has been of great value to many business interests, and all local forecasters are advised to sup-

plement their predictions accordingly. Such an estimate can easily be given in local work, but is most difficult in State forecasting. In my opinion it is important that forecasts of slight temperature changes should be allowed during cold weather and at the approach of hot waves in summer. While the probable local conditions may be estimated quite closely, the present rules do not favor such work in State forecasts. The absence of a temperature forecast now means that the temperature the following day may be as much as 8° or 9° warmer or colder than when the forecast was issued. In other words, at any temperature within a range of 18°. The range of temperature not requiring forecasts should certainly be less when it is considered how much frequently depends upon even slight temperature changes.

I believe that the forecaster who has shown himself competent should be given free rein; that he should not be hampered and restricted by set rules, but that he should be encouraged at all times to make his forecasts in the interests of the public; that if rules of verification must be used, every forecast which is really good should have a full verification. The more stringent the rules under which a forecaster works, the poorer his predictions are likely to be. These rules were primarily made and exact periods designated in order that definite percentages of verification might be determined, that comparisons might be made in the work of general forecasters, and between that of the latter and of local officials. Such a scheme is well enough, ordinarily, for the purposes of technical comparison, but I believe that forecasts would really appear to better advantage without such restrictions. I do not mean to suggest that they be made more indefinite or vague, or that even the plan of using exact periods be abolished, but that every word used in a weather forecast be considered to mean exactly the same as that understood by the public. Should such changes be made, causing the forecaster to feel absolutely free to express his opinion of the coming weather without having in mind technical verification, the forecasts would undoubtedly be much improved, be more easily understood, and be of greater value to all interests.

DISCUSSION.

Mr. E. H. Emery (New York). The subject of temperature changes is one upon which there are many views. He who attempts to establish verifying changes for the various months of the year should have some knowledge of the effect of such changes on the sensations experienced by a community. If such knowledge is not attainable, the best one can do is to derive it from his own experience of the effect of temperature changes on his own sensations. As some persons have a greater tactile sensibility than others, so the sensation of temperature varies with different individuals, the effect in the latter case depending largely upon the amount and character of the clothing worn and upon physical conditions.

Upon what change of temperature a forecast of warmer or cooler should be based is difficult to state. To test the skill of the forecaster, one set of rules is as good as another. But such test should not be the sole object of the rules. If the test of skill can be combined with the art of popular forecasting in such a way as to reach a popular approval, rules would be all that they should be. If a combination of this nature is possible, forecasts will not be without appreciation, especially in cities.

Just what percentage of a community is appreciably affected by a change, in the summer months, of 6° of temperature is not known; neither is it known what percentage is affected by a change of 4°. Again, in the winter months individual ideas on temperature changes vary. You might say that it was colder this morning than yesterday morning. Your neighbor does not agree with you, and he may say that, if anything, it is warmer. A look at the thermometer and you find that between the reading of yesterday morning and that of this morning there is no difference. The comparison might be extended to groups comprising a large number of people.

The effect of temperature changes, depending so largely upon the natural make-up of the individual, mode of living, food and clothing, occupation, and upon various conditions of the atmosphere, will not be the same in all cases. Merely lessening the verifying change of temperature will not result in forecasts becoming more popular. Until some definite information is at hand regarding the effect of different changes of temperature upon a community no advantage is gained by making the verifying change smaller.

The terms "slightly warmer" and "slightly cooler," however, should be employed in temperature forecasting only when such terms would better indicate the popular effect of the change anticipated. At certain temperatures the distinction between the terms "warmer" and "slightly warmer" or "cooler" and "slightly cooler" is often unimportant. On the other hand, at certain high temperatures during the summer months a rise of 6°, the verifying change for warmer in these months, is best indicated by the term "much warmer," and a rise of less than 6° by the term "slightly warmer," while a fall of 10° should be indicated by the term "cooler," and a fall, say, of 6°, by the term "slightly cooler."

If credits are given for changes smaller than those now used for the terms "warmer" and "cooler," temperature forecasting becomes more difficult. Under any code of rules for forecasting a forecaster has about as much as he wants to contend with, provided his main object is to make popular forecasts. In order to make popular forecasts his mind should be entirely free of all thoughts of verification. In consuming a portion of his limited time with the question of a trifling change of temperature he would benefit no one and be apt to overlook some of the very important features of the weather chart.

The terms "slightly warmer" and "slightly cooler" should be credited, but they should be credited in the same way as the terms "warmer" and "cooler," and they should be used in temperature forecasting whenever in the judgment of the forecaster they bear a more fitting relation between conditions existing at the moment and those expected to take place.

Mr. D. Cuthbertson (Buffalo). The forecaster very frequently finds the terminology of temperature forecasts too limited to make the predictions satisfactory to himself and to the public, whom he aims to serve. At present a change of 10° is the minimum which would verify a predicted change in temperature for the winter months. While that does not seem a very decided change for that season of the year, a smaller number of degrees is often noticed by the public and should be recognized in forecasting by such terms as "slightly warmer" or "slightly colder." If the verifying changes of temperature were smaller and the terms suggested were credited, greater utility of temperature forecasts would result and there would be greater satisfaction to the public. During the month of June, this year, 11 per cent of the

temperature changes that occurred at the stations reporting telegraphically to Buffalo were the verifying limit of 6°. During July, 13 per cent of the temperature changes at the same stations were the 6° limit. At Buffalo this limit occurred nine times during June and sixteen times during July, being 15 and 26 per cent, respectively. For those two months, then, 1 of every 8 temperature forecasts for the different districts was doubtful, and at Buffalo for the latter month 1 of every 4 forecasts was doubtful. It is probable that about one-half of this rather large number of instances, after puzzling the forecasters considerably, resulted in failures. These cases could well have been covered by the terms suggested and certainly with more satisfaction to both forecaster and public.

In this connection, another difficulty presents itself: The temperature change according to the actual thermometric readings, considering tenths, may vary considerably from the change according to the telegraphic report. For example, if the telegraphic report shows a change of 6°, the actual readings, considering tenths, may show as small a change as 4.1° or as large a one as 7.9°, a variation of nearly 4°. On this account, if verified from the telegraphic report, a forecast of "warmer" or "cooler" may be gained when the actual temperature change is but 4.1° and charged as a failure when the change is as much as 5.9°. While, on the other hand, a forecast of "stationary temperature" may be gained with an actual change of 5.9° and at another time lost when the actual change is but 4.1°. In either case "slightly warmer" or "slightly cooler" would have been appropriate and more satisfactory to all concerned.

The forecaster naturally makes his forecast so as to get the highest percentage of verifications. If the temperature is verified by the 8 o'clock readings the forecast is made accordingly. But when the public considers a temperature forecast, it usually has in mind the general thermal conditions for the period mentioned. The public has no knowledge of the rules obtaining in the verification of temperature predictions and rightfully takes for granted that the forecast is made in accordance with its way of thinking. Evidently we have here a condition of things in which a simple statement is expected to apply in two quite different ways. The public reads out of it one meaning, the verifier, according to existing rules, another. Sometimes the forecast holds good for both meanings, sometimes for but one of them. In the latter case, either the public or the forecaster will be disappointed. However, since the forecast is made for the information of the public it would seem to be advisable to make it so as to be of greatest use to the public.

There are circumstances which make the 8 o'clock readings undesirable for verification. To select a particular instant each morning and evening by which to verify predictions as to the thermal conditions for the whole period of twelve or twenty-four hours seems unreasonable to the public and probably unjust to the forecaster. At or near the time of these observations a rapid rise or fall in temperature usually occurs. When this takes place a little earlier one day and later the next, though both days or nights are practically the same in point of temperature, according to the existing rules for verification, a forecast would be called for which, according to the public, would not be realized. Temporary local conditions sometimes cause a similar annoyance. In view of this, my suggestion is to verify, if necessary, the temperature forecasts for a station by the general thermal conditions throughout the period covered by the forecast, as

shown by the thermograph trace. I earnestly believe that if the verifying change of temperature were smaller, and such terms as "slightly warmer" and "slightly cooler" were credited, and if, instead of verifying them by the 8 a. m. and 8 p. m. temperature, these and other temperature predictions were verified by the general temperature of the period as shown by the thermograph trace, the forecaster would be able to make better temperature forecasts and the official method of verification would harmonize with the public's estimate of the weather.

Mr. A. J. MITCHELL (Jacksonville). I ask your courtesy for five minutes, for a reference to the subject discussed in the previous section, as to changing the phraseology of forecasts and incorporating in them the words "slightly warmer" or "slightly cooler." The importance of this depends upon the section and the object sought to be benefited. It is perhaps of little importance in the interior and northern portions of the country, but along the Gulf and South Atlantic coasts it is a matter of serious importance. Suppose the morning observation shows 42° and you expect a fall of about 6°, not enough to specify, but only to say slightly cooler. That will give a temperature of 36° the following morning. Now, I took some comparative observations last winter for my own information. Of course we all know it is cooler on the ground than above, but these observations showed that there are frequently cases when the difference between the temperature of the office and the temperature two or three inches above ground is as much as 6°. The ground temperature, then, will be at least 4° lower than the office temperature, and that will give you a freezing temperature, 32° at least. The importance of this depends upon the object sought to be protected. Take the pineapple in Florida; it is getting into very bad company when it is near the freezing point, or even the temperature of moderate frost. Our forecast may not stipulate that it will be cooler; the forecaster knows that it will be, but it may be deemed a matter of insignificant importance and not to be considered, yet there is the pineapple seriously damaged by a temperature of 38°. The official temperature may not be anything like that, but down in the neighborhood of the pineapple it is almost freezing. The forecast may be correct and at the same time the pineapple and the vegetable growers have lost their crops. We credit the farmer with thinking more along these lines than he does. He has absolute confidence in our wisdom, and relies implicitly on our forecasts. All he does is to mechanically remember; you give the orders and he executes them. If we say cooler, he expects it to be cooler; if slightly cooler, slightly cooler. Let us be specific with him. These conditions are of importance in Florida, though they may be of small consequence elsewhere. Methods of protecting the pineapple crop in Florida by means of cloth or lattice covering have been found necessary, practically throughout the State, although the pineapple can withstand a moderate degree of frost. But to be certain of a paying crop, and a crop under all conditions, protection must be resorted to. Pineapples could not be profitably grown in Florida without the forecasts of the Weather Bureau. In observing warnings the people of Florida act as a unit.

Mr. N. B. CONGER (Detroit). The forecasting of the minimum temperature for each night, especially during a cold wave, is quite important, and if the maximum temperature forecast were entered as well as the minimum it would serve a good purpose, especially during periods of excessively high temperature. To forecast stationary tem-

perature or slightly warmer temperature would not be exactly right, but the maximum temperature, of a certain degree, would cover exactly the information people desire.

Mr. PATRICK CONNOR (Kansas City). I prefer the terms slightly warmer or slightly cooler. I think it is too much like splitting hairs to have to specify the maximum and minimum temperatures, although they should be used in verification of the night and day forecasts. I do not advocate specifying the exact degree.

SHOULD NOT TEMPERATURE FORECASTS BE VERIFIED BY THE READINGS OF MAXIMUM AND MINIMUM THERMOMETERS?

By Prof. A. J. HENRY, *Washington, D. C.*

Under the present system the forecaster attempts to make both a qualitative and a quantitative forecast of the temperature changes that are likely to occur within the ensuing twenty-four, thirty-six, and forty-eight hours. He attempts, furthermore, to predict the twelve-hour period in which the changes will occur, whether during the twelve hours ending at 8 a. m. or at 8 p. m. At the morning hour a forecast is made for the ensuing night and the day immediately following. For example, a forecast of higher temperature made from the observations of Monday morning would be cast in the following form: "Warmer to-night and Tuesday." This forecast affirms that it will be warmer during the twelve-hour period extending from 8 p. m. Monday to 8 a. m. Tuesday, and also during the concluding twelve hours of the period, or from 8 a. m. to 8 p. m. Tuesday. The amount of rise in temperature necessary to a technical verification of the forecast varies with the season, being 10° in winter, 8° in spring and autumn, and 6° in summer. The test of the accuracy of the forecast is made by comparing the temperature of the air, as determined by the dry-bulb thermometer at the end of each twelve-hour period (8 a. m. and 8 p. m.), with the temperature at the same moment twenty-four hours previous. If the temperature change equals or exceeds the limiting value for the season it is considered successful. If the forecast is accurate qualitatively but not quantitatively it is deemed a failure, as are also changes not forecast.

Under the system above described the forecaster is most concerned with the changes that are likely to occur at 8 a. m. and 8 p. m., and he naturally brings into play all of his experience and skill *in determining the probable temperature at those two hours.*

The question at issue is, Should not temperature forecasts be verified by the readings of maximum and minimum thermometers, rather than those of the dry thermometer, at 8 a. m. and 8 p. m.? In answering this question, our first effort should be to determine whether the readings of maximum and minimum thermometers more nearly represent the general temperature conditions of the day than do those of the dry thermometer at 8 a. m. and 8 p. m.

It is believed that, as a rule, there is little choice between the 8 a. m. and the minimum readings, so far as showing the daily changes is concerned, and this is especially true west of the one hundredth meridian, where the daily minimum occurs very nearly at the time of the morning observation. As between the maximum reading for the day and the 8 p. m. reading, the former probably represents the character of the day better than the latter. The 8 p. m. reading, during the season of thunderstorms and local showers, does not always repre-

sent the true character of the day. A thunderstorm occurring a few minutes before the observation hour, on the warmest day of the season, may lower the temperature 10° to 20°. And thus we may have the curious anomaly of a forecast of cooler weather being successful on the warmest day of the year. On the other hand, we should remember that a thunderstorm or local shower is also liable to occur at the time of maximum temperature and thus spoil a forecast that in all other respects was correct. This much is to be said in favor of the maximum temperature, viz, it falls not far from the middle of the day, and more nearly represents, in the popular mind at least, the character of the day as regards temperature.

In some parts of the country there are very few changes in the daily readings of the maximum or minimum thermometers in the warm season equaling or exceeding 6°. Thus, at Augusta, Ga., during July last, there were but three such changes, while the 8 a. m. and 8 p. m. readings changed by amounts equaling or exceeding 6° as many as seventeen times. These changes were due in almost all cases to the occurrence of local showers in the afternoon. At Washington, D. C., the changes in the maximum and minimum readings were only half as many as in the 8 a. m. and 8 p. m. readings. In the case of Augusta, forecasts verified by the maximum and minimum thermometer readings would have been of greatest service to the public. At Washington, D. C., it would have made little difference to the public which system had been used. In order that some tangible results may flow from this discussion, I would suggest that all forecast officials and others who desire a change from present methods put their views in writing and forward them to the Central Office.

DISCUSSION.

Professor McADIE. It is a delightful experience to me to hear several "cries from the heart" here, and I am glad to learn that there are other marksmen in the world who are pretty well convinced that the trouble lies with the target, and that the gun is not as good as it should be, but that the man is all right.

One of the great problems of the Bureau in California is the forecasting of frosts for the citrus fruit growers, and it is of the utmost importance to say colder, even if but 2 degrees colder weather be expected at such critical times, so that there may be no let up on the part of the orchardists in protecting their fruit. It is just at such times that the opinion of the forecaster is most anxiously awaited, and to hamper him by verification requirements is unwise. Often a temperature fall of 2 degrees may occur between 5 a. m. and 7 a. m. The sun rises, say, at 7.26 a. m., and the minimum temperature probably occurs then. The observation is made at 4.40 a. m. Therefore, the change between the 5 a. m. (8 a. m., seventy-fifth meridian) observations might not fairly represent the conditions. Under such conditions (and these do occur) the forecaster must choose between losing his forecast, so far as official verification goes, and saving the fruit, or winning his forecast and letting the orchardists surmise for themselves whether protecting methods should be energetically operated.

With regard to maximum readings when the temperatures are in the neighborhood of 110°, as is the case frequently on summer afternoons in the great valleys of California, the forecast of warmer weather could hardly ever be made and verified under present conditions. Yet the public is greatly interested at such times, and wide-

spread comment is made should the temperatures exceed those of the previous day by a few degrees.

Both with temperature and rain forecasts, it seems to me, the matter of verification should be given less weight than at present. The method which I prefer is to study my errors. I am less interested in the forecasts which come right and which the public applaud than in those cases where I slip up—where, for example, on a fair-weather type of map rain falls, or where when a forecast of frost is made there occurs a shifting of the wind and a warming up instead of the expected fall.

It seems that the maximum and minimum temperatures afford the only true means of verifying the temperature forecast. Sudden changes are of frequent occurrence during local thunderstorms, and in many instances the maximum temperature is higher, but the current at 8 p. m. is lower than on previous days. While the forecaster may forecast cooler for to-morrow and verify, yet if the maximum temperature is higher than on the previous day the public regards the prediction a failure.

FACILITIES FOR SYSTEMATIC STUDY OF CORRESPONDING WEATHER TYPES.

By Mr. F. H. Brandenburg, *Denver, Colo.*

In the summer of 1900 it was my privilege to spend a short time in the forecast division of the Central Office, and in making practice forecasts for the United States I often wished that I had at hand maps of a type similar to the one under consideration from day to day. It is needless to say that in searching for these much time was consumed without satisfactory results, and this caused me to consider seriously the matter of devising some method of classifying maps according to type. Consultation with Professor Garriott encouraged me to undertake the work, and, on my return to station, plans were formulated for a system of ready reference to all weather types shown by the a. m. maps issued by the Central Office during the past ten years.

My purpose in bringing this subject to your attention is not to lay down any procedure for study, but merely to describe facilities which it is believed will prove a valuable aid in quickly refreshing the memory as to the different conditions and types that obtain during any particular month.

The size of the original maps precludes their use, and a small base map of the United States was therefore drawn and printed on half sheets of letter paper, a space being reserved on the left for notations. This space was divided into two columns, at the top of which the words "high" and "low" were printed on one set, while on the other set the words of the heading were reversed. As regards the lines to be reproduced, a sketch of the principal isobars, with the regions of high and low pressure suitably marked, was considered sufficient. The period covered being about ten years, 3,600 or 3,700 maps were sketched. These sketches in turn were duplicated by means of carbon paper, the number of maps for each date depending upon the number of "highs" and "lows" considered valuable in the classification. In some instances one map was sufficient for the set of high areas and one for the set of low areas, and occasionally as many as eight in all were necessary: in general four sufficed. The next step is to outline on each small map the shaded areas shown on the Washington map

of the succeeding day, and by shading these areas with a green pencil we avoid interfering with the isobars, which are drawn in red. Thunderstorms were indicated by a small green cross, and the regions visited by temperature changes of 20° were outlined in black. Mention has been made of two columns on each sheet at the left of the map. In the appropriate place note is made of the location of the high and the low areas. Every one of these notations is given first place on some map, and the distribution is made in accordance therewith, every map finding a place in some one of the ten or eleven districts adopted. For example, let us take the high areas for January. A map for each date on which such an area occupied the British Northwest Territory will be found in its appropriate subdivision, and the same is true of any given high area, no matter in what part of the United States it is located. In the subdivisions the maps are arranged according to type, and the total number of dates, as indicated by the number of maps, shows at a glance the prominent features of the pressure distribution for January. Arranged in two small boxes, "highs" in one and "lows" in the other, with cards to indicate the different subdivisions, it is a matter of only a few moments to learn whether any particular type of map is rare or common, and whether pronounced conditions follow.

Since the Washington maps must be referred to for information as to the conditions that obtained more than twenty-four hours after, it is very desirable that they be conveniently arranged. It has been found best to bind three months—say January, 1892, 1893, 1894—in one cover, thus making only three or four books for the entire period. Study of the temperature is facilitated if the changes as shown by the table on the map of the next day are written near the respective stations on the map under consideration. As the number equaling or exceeding the stationary limit is small as a rule, one is well repaid for the work of entering the data, red figures being used to indicate plus and blue to indicate minus changes.

As the current distribution of pressure and whatever important conditions it brought about regarding temperature and rainfall are graphically shown on each small map, I am of the opinion that the use of this system will facilitate the study of all types and necessarily cause a general improvement in the daily forecasts, for no mind is capable of retaining without constant study a clear impression of the weather changes peculiar to each of the twelve months in the different geographical divisions of the United States.

The CHAIRMAN. Mr. Brandenburg has devoted a great deal of time and labor to this subject, and it is only by the expenditure of time and labor that we can make any advance in forecasting or in any other line of work.

HOW TO MAKE THE SYNOPSIS INSTRUCTIVE TO THE PUBLIC.

By Mr. F. P. CHAFFEE, *Montgomery, Ala.*

The daily weather map is the most popular publication of the Bureau and its most constant means of communication with the public. It is the medium through which the Bureau not only conveys its forecasts of coming weather events, but shows in the most graphic way the conditions on which such forecasts are based.

Aside from its value as a public guaranty that the Bureau's deductions are based upon reliable and authentic data, it gives the current

weather conditions and the extreme conditions in all sections during the previous twenty-four hours, which information is often of such general importance as to materially influence trade conditions over the entire country. Now, acknowledging the great importance of this publication, it seems that the synopsis—the epitome, as it were, of all the information conveyed and upon which the forecasts are based—is one of the most, if not the most, important of its features.

In a great number of cases those who receive the maps have not the time to study out the details, and a well-couched, concise synopsis is all they desire. Just as one glances over the head lines of the morning paper for such items as he desires to read, so does the hurried business man glance over the synopsis of the weather map for the information which may be of import to his business. Should he find any special mention of unusual conditions over sections in which his interests are involved, then he may look up the detailed reports from such districts. So, in my opinion, the summary or synopsis, which is the very index of the entire weather map, should be most carefully prepared.

Real popular interest in the work of the Bureau practically dates from the time it began the issue of the weather map. Prior to that time the daily reports were bulletined in mere tabulated form, which but crudely showed the geographic distribution of the various conditions as they developed and moved across the country, whereas the weather map, the issue of which began at quite a number of stations in 1887, shows the inception, development, and progress of the great atmospheric disturbances in such a graphic way as to engender an interest in the science of meteorology. Those who received the maps regularly soon began to note the general regularity with which certain weather followed certain conditions; they began to appreciate the difficulties incident to weather forecasting; and the criticisms of the Bureau's work, which prior to this period had been mostly of the facetiousness begotten of ignorance, became more intelligent. It was not long before the regular recipients of the map began to draw their own conclusions, and were thus able to amplify the official forecasts in their application to their own immediate vicinities. Soon the weather map was introduced into the schools, more as a curiosity at first, but now a large number of educational institutions use them to advantage in their daily class work.

If what has been said so far on this subject has tended to substantiate the statement previously made—that the weather map is of great importance to the public in various ways, and that the synopsis of the information on the map is next in importance to the map itself—then every effort should be made and every reasonable latitude allowed in preparing the synopsis in the most interesting style, not only that it may convey the bare facts as shown by the reports; not that it is colder here, warmer there, and that rain or fair weather prevails over certain areas, but that the cause and effect should be woven into the woof of the synopsis, so that each map may in turn present a lesson in meteorology that will appeal to the public.

It is thought that such latitude in the preparation of the synopsis as is here suggested could be safely allowed station officials without danger of their drifting into theoretical speculations which might discredit the Bureau.

Then, again, the treatment of the matter contained in the synopsis varies with the seasons. For instance, during the hot wave and the drought which prevailed over such an extent of country during last

June and July, the excessively high temperatures and their comparison with extremely high temperatures of the past, and any rain that occurred over the districts affected, were the most prominent features in which the public was interested. At other times a cold wave or a killing frost in the great corn and wheat belts of the West may be the central topics for discussion, while, at another time, excessive rains over large portions of the cotton belt, when the great staple of the South is in its most precarious stage, may be subjects for more elaborate treatment than ordinary.

The special bulletins issued to the press by the central office, covering unusually severe storms, floods, etc., often contain information which is of value to the station official in preparing the synopsis.

The charts of maximum and minimum temperatures by decades will be found useful in reference to temperature extremes and their comparison with those of previous years. A new issue of such charts, corrected to date, would, I am sure, be appreciated at map-issuing stations. All local data, such as high winds, excessive rainfalls, heavy snowfalls, first and last killing frosts, and temperature extremes, should be kept up to date and ready for convenient reference in writing up unusual local conditions, for, while the public does not care for a map embodying constant comparisons of current conditions with those of the past, it does appreciate such information when any unusual weather prevails, particularly when such comparisons are deftly woven into the synopsis in a clear and concise style.

In no branch of business, either commercial or governmental, is there a more complete or more accurate and rapid system of collecting reports and disseminating information than that employed by the Weather Bureau in collecting and publishing the results of its twice daily atmospheric surveys. Without considering the limited time allowed for the preparation of the maps, it is not considered presumptuous to say that these publications are, as a whole, most creditable. But so many and such varied interests look to the Bureau for information which is of the most vital importance to them that, in my opinion, every effort should be made to make the daily weather synopsis as instructive and interesting as is consistent with that brevity so necessary to expedition.

It is hoped this matter may meet with that discussion it seems to merit. It is by such discussion and interchange of views that we may be mutually helpful and the great public interests we serve be benefited.

It is thought that in many instances a card publication containing the synopsis and the forecasts would, to a great extent, answer the interests now served by the complete weather map, except to those who desire it for study.

DISCUSSION.

Dr. R. B. HARKNESS (Houghton, Mich.). In entering upon this subject the first fact that occurs to one is that before a weather synopsis as published on a map or bulletin can become an educational factor it must be intelligently and regularly read by those whom we wish to instrnct. A primary necessity, then, is to make our synopsis interesting and readable. Our article each day is practically like any news item written for a daily paper, and it will be read only under the same conditions, and should be written with the knowledge that if it be not concise and interesting it will not be read at all and therefore fail of its intended purpose.

It is probable that the majority of persons who have access regularly to a bulletin or map read only the forecast as published and do not try to discover for themselves the laws which have guided the person making the forecast. There is a surprisingly large number of persons, on the other hand, who, upon casual meeting, discuss the morning's map or bulletin in a way that leaves no doubt as to the care with which it is read or the depth of their knowledge of the subject.

As it is necessary to gain a reader before we gain a pupil, it is not out of place to determine what the elements of a good synopsis are and what contributes to making it better and more readable.

A good synopsis, then, is one that in a clear, concise, conservative, and interesting manner, in good English, covers the weather conditions of the country from day to day.

In writing a synopsis day after day we are inclined to fall into a routine method of noting the conditions, i. e., we mention the position of the "highs" and "lows," then the rainfall, then the rise or fall in temperature, then miscellaneous phenomena; in this shape they can be followed only by one who is thoroughly used to them, and to the beginner they convey no hint of the relation they bear to each other, which is one of the prettiest points available for use in our synopsis. The association of falling pressure and southeast winds, rising temperature, and increasing cloudiness, with rain, makes a typical picture to which we like to call attention, and the presence of one suggests the others. Unfortunately, these conditions do not invariably accompany each other, and it is not the typical storms, but the atypic ones, which require study. Mentioning a low area approaching from the Northwest, following it from day to day, with all its attendant phenomena, until it passes off the map, forms one of our best routine synopsis methods.

The instruction given by daily synopses can not, of necessity, make advanced meteorologists, but it can teach the reader to follow the progress of conditions, so that he may seek for himself the reasons for the forecast given, and, later, make his own forecasts. A few attempts at forecasting for himself will probably materially increase his idea of its difficulty and of the efficiency of the Bureau, and it is almost invariably the case that when a man has interested himself in the map and in meteorology and becomes well posted he is thereafter among our stanchest friends and supporters.

Among the classes of persons whom we can best reach the following are the most important: Farmers, grain and produce commissioners, cotton factors, tobacco dealers, railroad men, marine men—lake, sea, and river—the amateur meteorologist, and high school pupils.

The first three classes are men who deal in products which are directly influenced by weather and to whom a knowledge of weather is a distinct business advantage; they go about getting it in the same thorough way that they do information concerning any other branch of their business. The blackboard weather map in the business exchanges is a very good place to gain an idea of the business man's ability to follow weather conditions; the progress of a storm is followed there as closely as the fluctuations in the market, as it is, in fact, frequently itself the cause of such fluctuations. When the attention of these men is called by the synopsis to any regular rule by which the probable direction of a storm can be estimated, there is usually no necessity for repeating it; for example, when the speculator or the horticulturist or agriculturist sees stated as a general fact in the morning's synopsis that frost is probable along and north of an isotherm of 40° the lesson is not lost upon him.

Railroad men as a rule simply accept the Weather Bureau's warnings of a heavy snowfall or rainfall or other unusual conditions and prepare fully for them, and know that "wolf" is very rarely cried without occasion.

Probably the closest students of meteorology we have are the marine men. With them the interest is vital. When the ship captain is in a harbor where a map is issued, his study of the nearest available copy is of the closest. He is rather a specialist in forecasting, as he has practically but two elements, wind and barometer, for one station, his ship, from which to make his forecast. The synopsis can not be used as a method of instruction in his case, but that he is reached in another way by the Bureau is impressed upon one by the number of copies of Professor Garriott's "Wind-barometer table for the Great Lakes" which one sees posted prominently in cabins where only publications of value can gain wall space.

The man who is interested in meteorology as a scientific study for pleasure must not be forgotten. His information is principally gotten from Weather Bureau publications, and his train of thought is in sympathy with that of Weather Bureau trained men, making it a pleasure to write for his benefit, and still more of a pleasure to discuss later with him what you have written.

It is probable that the best results are derived from the synopses which reach high school pupils. In the high schools of nearly every city a critical study is made of every day's map, and the synopsis is read very closely, and any point of instruction contained in it is given due attention. It is very desirable to start the interest of such a class by giving them a talk on the Weather Bureau, the map, means of forecasting, general laws of storms, etc., at the beginning of the year, and having them understand that they are always welcome visitors at the office, and that one is glad to discuss the work of the Bureau with them at any time. Of any given class of readers of the synopsis, the greatest and most far-reaching educational results are probably derived from those which reach high school pupils.

Summary.—A synopsis should be concise, interesting, conservative, accurate.

It should be written bearing in mind the diversified interests and different degrees of meteorological knowledge of its readers.

Each synopsis can not convey a lesson—the lesson must be included as opportunity offers.

Atypical storms can convey a lesson only when the typical storm is known. Hence, for so general a lesson as a synopsis conveys it is probable that the use of a typical storm is best.

Remarks in connection with frosts on the map are of great value, particularly the first in autumn and those occurring late in spring.

In noting frosts early in autumn and late in spring mention of the average date of the earliest and latest, respectively, is of interest.

Knowledge of the amount of snow on the ground in the vicinity of navigable rivers is a necessity in forecasting probable stages.

A purely routine synopsis can hold the interest of only the most enthusiastic reader.

In mentioning any except the best-known cities give the name of its State.

The synopsis is a condensation of the data as entered and to particularize too much is merely to repeat matter entered elsewhere.

Read carefully the synopses written by other men in the Bureau.

Interest and variety are given a synopsis:

By a local note, as "the storm which visited this vicinity yesterday," etc.

By mentioning of especially high or low temperature or barometer or particularly heavy precipitation, etc.

By comparison of existing conditions with previous records.

THE PUBLIC AND THE FORECASTER.

By Mr. HARVEY M. WATTS, *Philadelphia Press.*

However one may deplore the prevailing but ill-founded belief as to the inaccuracy of the daily forecasts for specific localities, which in some centers has reached a condition of almost universal acceptance, the existence of such a state of things can not be overlooked. The belief, as everyone who is familiar with the substantial accuracy of the Bureau forecasts knows, is the result of careless comparison, and of false perspective, by which all the errors are lumped in a rather formidable phalanx. But the belief being what it is, the question arises whether, utilizing exactly the same data as we have now and pursuing practically the same method of forecasting, public confidence can be restored and the work of the Bureau forecasters for given areas viewed in a new and friendly light. My answer is that, even with the known percentage of error remaining what it is, a more favorable impression can be created by the Bureau forecasts if the forecasters will but recognize certain physico-social conditions that are seemingly overlooked to-day in too many instances.

The unfavorable impression that is more or less prevalent to-day results, obviously, in the first place from the bald unverification of positive forecasts; in the second place (and this often causes more irritation and arouses more criticism than a bald error) from vague, indefinite, negative forecasts, that are silent as to the prospect of change or continuance of a given type of weather that is affecting popular imagination; when, for instance, during a hot spell, the forecast is silent as to temperature while mentioning wind direction and general outlook, and runs somewhat as follows: "For eastern Pennsylvania, fair, southwesterly winds." In the third place, and this seems to me to possess a significance which has never been fully recognized by the general forecasters, it is the bad forecast (bad positively or negatively) that covers the great population centers that destroys confidence in the Bureau forecasts in a way that not only gives the Bureau a poor reputation in that given center, but which, by reason of the discussion of the matter in the public prints that possess a large circulation and a national influence, tends to condition a belief in the inaccuracy of the Bureau forecasts in districts where the results are quite favorable to a belief in the substantial inerrancy of the service. When it is remembered how large a percentage of the total population of the United States is crowded in or near cities, it must be self-evident that in a given instance a forecast might fail to hit the mark for the rural sections of the States of New York and Pennsylvania five times out of six without attracting the attention that one slip out of six would make for the great population centers of which New York City and Philadelphia are the respective foci.

It is the great population centers to which the daily forecast is of immediate moment. It is the public in these centers, which possess a population equal to that of entire States, whose daily social and busi-

ness affairs are of that complex character that leads them to study and use the daily forecast and to discuss its successes or failures (particularly its failures, the successes being taken for granted) and to pass judgment on the Bureau accordingly. This judgment may be, and often is, capricious and foolish in its unjust severity, as handed down in private circles and in the public prints, but it is a judgment the Bureau must meet and overcome, and it is because the forecast has this pressing physicosocial value in the centers of a maximum population density that the bad forecast is given an intensified effect far above a similar error for a rural district where the inevitable drift of the weather, whether foreknown or not, is taken as a matter of course, and where isolation and the lack of communication prevents that common belief being developed that makes the cities the centers of criticism.[a] For in the cities, by the well-known law of collective suggestion, when once there prevails the belief that forecasts are usually wrong, it is taken up by almost everyone and, spread by the newspapers, creates a general psychological condition of hostility that tends to run the country over, and to discredit the Bureau in a way that is most difficult to counteract.[b]

In meeting the issue that confronts forecasting to-day the most effective thing to do is to attack the problem at the heart. The positive forecast, perhaps, can not be improved under present conditions, but the negative, vague forecast, it seems to me, can be specifically changed for the better, and in the great majority of cases can be avoided altogether. At all events it should be a last resort. Every effort should be concentrated on giving positive forecasts in those particulars that happen to be arousing public attention. And yet many forecasters err in this issue, and the error, a careful examination of the data on given occasions has convinced me, is often without determining reason, so far as meteorological factors go. During a hot wave, for instance, particularly for the great population centers, where its prevalence is a matter of life and death and sickness and checks daily business, everything in the forecast should bend to the question of temperature changes—during a drought or a rainy spell, to any change for the better in the matter of storm phenomena; the frank "no change" being very much more welcome, and, if verified, much more likely to enhance the reputation of the Bureau and forecaster, than the forecasts that seem to avoid the issue on which millions wait with feverish anxiety. Better be definite, even if wrong in the important particular, than continually vague, so that the public prints are forced to declare that the forecasts are "meaningless."

With full knowledge of the difficulties that beset the forecaster, I

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[a] Nothing that is said here should be construed as indifference toward the liberal extension of daily forecasts through the rural districts by means of the rural free delivery service of the Post Office Department or by any other means. On the contrary, such a distribution of forecasts is most commendable, though it is certain when the entire country is supplied with the daily forecast the tendency toward a uniform friendly or unfriendly attitude toward the Weather Bureau's work, now a marked feature of the psychology of city populations, will be repeated in rural districts.

[b] A case in point occurred a few years ago, when, without any well-grounded reason for it, a belief developed in Boston and vicinage that the weather forecasts then issued by the Blue Hill Meteorological Observatory were always right as contrasted with the Government forecasts. Blue Hill never made any such claims, and both the observatory and the Bureau were embarrassed by the belief. In lesser degree and with less reason, there is a tendency on the part of some in New York to view the so-called "Herald" forecasts as more correct than those of the Government Bureau, but the matter will not bear examination.

believe the negative forecast can be vastly improved upon, and particularly for great centers of population. I am absolutely convinced that a marked improvement would set in if the present habit were abandoned by which great population centers are classified, lumped, or tagged on, as it were, to extensive geographical areas, the forecast being made general enough to cover the entire district. Such a forecast may be accurate enough save in the damning particular of the weather of the cities on the periphery of the district. Let me explain. It has happened again and again that the forecast for the district that includes the Philadelphia-New York population area (the largest in the country within the given ellipse which has a major axis of about 100 miles and a minor of about 50, and represents an aggregate of over 5,000,000) may hit the conditions that prevailed on the southern, northern, or western edge of the district, but absolutely miss it for the central or eastern area comprising these two great urban regions. Since it is these city millions who spread the belief as to the success or failure of the daily forecasts, what doth it profit a forecaster to hit it for the wilds of western Virginia and the mountains of western Maryland and miss it for the New York-Philadelphia-Baltimore district? Such a forecast is the most dangerous kind. One of the most striking examples of one of this type is that made for August 1 and 2, 1899, which read as follows:

> Forecast for Tuesday and Wednesday: District of Columbia, Eastern Pennsylvania, New Jersey, Delaware, Maryland, and Virginia, fair Tuesday and Wednesday; variable winds, becoming southerly; continued high temperature for two or three days.

This proved to be bad in every way so far as a large part of the area covered was concerned. It was not true for Philadelphia and vicinage, but I believe was verified by the conditions in northern Virginia. But what if this were the case? Are our great industrial and economic centers to be tied onto undeveloped, sparsely settled areas and forecast for as if by inadvertence? I believe the time has come when such forecasts should be abandoned. To begin with, the signal importance of the population centers should be recognized, so far as the daily forecast goes, and special attention should be given to specific forecasts for these limited but highly important areas. Whether this specificity can be secured by going back to the old method of local forecasting for a given district, of course, with modern improvements, I leave to the more practical men in the Bureau to solve. Much may be said for or against the proposition, but my own view is that the great population centers should be arranged as subdistricts: the forecasts for which should be made from a given office in the district, on the spot as it were, under office conditions that will give the observer and forecaster full opportunity to study the local anomalies; to familiarize himself with the physical surroundings by macroscopical examination of the skies; and to know those facts that are not revealed by a study of mere printed surface data, which will never come to one by mere chamber work, which can only be gained by familiarity with the given locality, and ignorance of which in almost every case is what upsets the general headquarters forecaster and nullifies his forecast.[a]

[a] Since this was written Professor Moore's announcement that he intends developing independent observatories in certain centers of population, it must be evident, will meet the issue here raised in a striking manner. With such observatories in being, the forecasting for the given areas under discussion in this paper should be susceptible of great improvement, not only in kind but in degree of positiveness and accuracy

Speaking for the Philadelphia district, I have seen the eastern Pennsylvania, Delaware, and Maryland forecast, which covered too wide an area, miss the mark for the city and its vicinage day after day on account of local conditions set up by an oceanic high area, which deflected storm movements from the west so that the city escaped the showers continually predicted by the Washington office. Now, the local effects of this "high" is one of the Philadelphia district's anomalies. Other cities, other population centers, other limited geographical districts, have other anomalies, which can only be ascertained by a continual study of the skies in the large, instrumental facts being supplemented by a general knowledge of the local aerial aspect under given general conditions. I am told by observers and forecast officials that at present they have not the time to make these studies "in the large," but I am sure that the present head of the Bureau, who has done so much to advance the practical work of the Bureau, who has urged the forecaster to get away from the dull and deadening routine, will welcome any plan that solves this problem, and will give the local official all the time he needs if he can show substantial results.

In conclusion, I am convinced if the forecasts for the great population centers be more carefully looked after, if the negative forecasts be reduced to a minimum, that, even without any marked increase in the percentage of accuracy being made, with meteorological knowledge being what it is to-day, the public impression as to the character of the forecasts will be wholly changed, and for the better; confidence will replace skepticism, and the positive successes, and not the failures, will dominate popular imagination.

THE TELEGRAPH AND THE WEATHER SERVICE.

By Mr. J. H. Robinson, *Washington, D. C.*

Our present chief once said that without simultaneous observations and the electric telegraph discoveries in meteorology would be of little value. Judging from this remark he has a high and proper appreciation of the value of the cooperation which has been given the national weather service by telegraph officials.

At our last convention several speakers advised the cultivation by the Weather Bureau people of the good will of the press. No reference was made to the uniformly cordial relations which have existed for the past thirty years between our observers and their closest coworkers, the telegraph officials and operators. Nor does it appear necessary, in the presence of men who have for years maintained close and agreeable business relations with telegraph officials, to dwell upon the importance to themselves and to the service of cultivating and preserving, by all legitimate means, the friendship and good will of men who have, as a class, been so closely identified with the origin and development of the United States weather service. In the early history of the telegraph its officials noted, in making their line tests, the advance over the country of storms. During the period from 1830 to 1840, Espy had demonstrated that areas of rain advanced eastward from the interior of the country to the Atlantic coast, and that severe storms reported in the West and Southwest were usually experienced within a period of one to three days in the Atlantic coast district. In 1850 Mr. George B. Prescott, an employee of one of the telegraph companies then in existence, following in lead of Redfield, Loomis,

Espy, and Henry, declared that our Government should establish storm-warning stations along the New England coast and at other points. In the same year Mr. Joseph Brooks requested Mr. Prescott to employ an agent to make daily observations at New York. At the same time observations were also taken at Boston and Portland, Me., and exchanged by telegraph. These reports were found to be of considerable value to steamers plying between New York, Boston, and Portland. Mr. Prescott also advocated the inauguration of a similar system of telegraphic reports upon a larger scale, and stated that, in his opinion, a service of this description would be of great value to shipping and coast property.

In the late sixties the telegraph officials again demonstrated the value of telegraphic reports of weather conditions by furnishing daily reports of weather reported along their lines at the request and expense of the Cincinnati Chamber of Commerce.[a] It is a historical fact that these reports were utilized in the preparation of daily forecasts by Prof. Cleveland Abbe. It will thus be seen that the telegraph performed pioneer service in connection with the present Weather Bureau establishment, and that full credit should be given the telegraph companies for the important part assumed by them in originating our service, and for the more than business interest they have taken in our work since the service became a regularly organized department of the Government. This interest has been shown on many occasions when telegraph communication has been seriously interfered with by storms. At such times they have given us the only wire they had in operation to the exclusion of all other business, and they have almost invariably given us the best service at their command.

The growth of the Weather Bureau system of reports and warnings has been coextensive with the growth of the electric telegraph, and the collection at Washington within the space of an hour of reports of simultaneous observations from an area which covers nearly one-fourth of the surface of the earth, and an equally rapid dissemination of forecasts and warnings, a feat which a few years ago would have been declared impossible of accomplishment, now constitutes a part of the daily routine work of the Bureau. The uniformly splendid work of cooperation of the telegraph companies can not be ascribed to purely business considerations. The telegraph officials have not viewed our work wholly in the light of a business proposition. The many courtesies we have received at their hands have been prompted by a real regard for coworkers in an important and valuable branch of the Governmental service, whose origin and history has been so intimately associated with the great and progressive service which they represent.

IMPORTANCE OF RIVER-STAGE FORECASTS OF THE MISSISSIPPI AND OHIO RIVERS AND TRIBUTARIES IN PERIODS OF LOW WATER.

By Mr. P. H. Smyth, *Cairo, Ill.*

Before taking up the topic assigned to me I desire to say a few words regarding river forecasts and warnings which are issued in times of fl od.

A little over thirty years ago, or before the advent of the Associated Press and the Government river gauge, the newspaper correspondent

[a] See note embodying statement relating to this matter, p. 225.

was the principal agent by which the general public received its river information and its warnings of impending danger from flood.

In those days the larger western newspapers had correspondents at every important place on the rivers. Each correspondent improvised his own river gage, which, as a rule, consisted of a pole or stick driven into the ground. When the time arrived to make a reading the correspondent pulled up his gauge, noted the rise since the preceding observation, then drove it down again at the edge of the water.

Of course the height of the river could not be given, so, in order to convey some idea of the extent of the flood, if it happened to be in flood time, the correspondent would telegraph his paper somewhat in this style: "The river has risen 2 feet during the past twenty-four hours, and is now at the lower end of the old stump on old man Flood's place." As old man Flood's place was well known along the river, and the old stump was a familiar object to rivermen, conjectures at once became rife as to what would be the outcome in the lower valley. Very little attention was given to the amount of the twenty-four-hour change when the rivers were falling.

How different it is to-day! One who watches carefully the daily reports and bulletins issued by the Weather Bureau and published in the daily newspapers can accurately picture the crest of the flood wave as it moves down the valley. He can foretell to a certainty the day and even to within a few hours of the time that the crest will reach any particular place. Mentally he draws his hydrographs, graphically picturing the flood waves passing down the tributary streams, and from data furnished him by the Bureau he accurately calculates the time it will take for these waves to reach the main artery and, approximately, the effect they will have on it.

On receipt of the Weather Bureau warnings, stock, farming implements, grain, and in fact all movable property are transferred to places of known safety, thus reducing to a minimum the destructive effects of the flood. Lumbermen, in addition to protecting their sawmill plants, take advantage of the information by preparing to float timber to their mills. The value of flood warnings is so obvious, even to those who are not directly interested, that to further particularize is unnecessary.

The river forecasts issued by the Weather Bureau in periods of low water in the Mississippi and Ohio rivers and tributaries are, in my opinion, next in importance to river forecasts issued in times of flood. In periods of low water river-stage forecasts are of great benefit to lumbermen, rivermen, and transportation companies.

Lumbermen are busy at all seasons of the year; they must keep their mills supplied with logs at all times, and to be able to do this they must take advantage of every opportunity. They can not wait until the opportunity itself is present, but must anticipate it, and be prepared for it when it comes. How can they do this more practically than by consulting the published reports of the Weather Bureau?

I have had lumbermen say to me that the lumber business has reached such proportions that it would be almost impossible to satisfactorily conduct it now without the daily reports of the Bureau. The movements of lumber barges are governed almost entirely by the information contained in the published reports and the forecasts of future river conditions. As an illustration of the value of river forecasts in times of low water, I cite the following: In the first few days of October, 1898, the lower Tennessee river was at a very low stage; a decided rise occurred in the upper river from the 4th to the 7th, and this information

was distributed by mail and telephone throughout the section that was likely to be effected and to persons having interests in that section. A few days later a lumberman wrote to me that he had instructed his logman to start with only about 100,000 feet of logs, but upon receipt of this information he immediately wired him to bring out 175,000 feet. His telegram reached his logman at the last telegraph station on his way to the timber lands. No doubt that many such cases occur which are never reported.

When lumber barges are started down the river to go into some chute to load logs or lumber, the logman is instructed as to the depth he shall load. These instructions are based to a great extent upon the information received from the Weather Bureau. It sometimes occurs that after the barges have been gone two or three days the lumberman is informed that the river will rise to a certain stage by a certain time. Upon receipt of this information he immediately sends word to his logman to load to a greater depth.

The great volume of business done by the dealers in lumber represents a vast amount of capital, and gives employment to thousands of men. The product of about 125 sawmills is handled and distributed from Cairo, and, as fully 75 per cent of this is carried on the rivers, one can readily see how indispensable information pertaining to existing and approaching river conditions is to the lumber interests, particularly so at such times when a rise or fall of 1 foot in the rivers, if not anticipated, would mean a considerable loss or gain.

To river men the river forecasts, in periods of low water, are of interest and value, not so much on account of the information regarding the probable stage, but as regarding the change, whether the river is to rise or fall or to remain stationary. I have reference now more particularly to the great "Father of Waters" below the mouth of the Missouri. From a comparatively clear stream above the mouth of the Missouri the Mississippi becomes a veritable alluvial stream after its junction with that river. "Its bed is a mass of moving and rolling sand, pushed along by the river currents, and to this is being constantly added the soft materials eroded from the banks where the currents press against them." Every rise is followed by a greater or less shifting of the channel line, and "bars" and "reefs" are formed, thus rendering navigation uncertain and at times dangerous. If after a rise the river falls rapidly, insufficient channel depths result; but if the fall is gradual, the river currents cut away the bars and leave a fairly open channel. The longer the cutting process the better the channel, provided, of course, that the river does not get extremely low. It is evident, then, that although fairly good stages may be shown on the river gages, the channel depth may be inadequate for safe navigation, and vice versa. It is for these reasons that the navigator is more interested in information pertaining to probable river changes than he is in river stage forecasts.

Transportation companies would find it very difficult to conduct their river business without the river forecasts and the general river information now furnished them by the Bureau. I have seen passing down the river a tow comprised of 51 barges carrying 1,275,000 bushels of coal. This quantity of coal, if loaded in cars, allowing 30 tons to the car, would require 1,611 cars, or a solid train nearly 10 miles in length. From this statement alone I judge can be formed a very good idea of the extent of river traffic.

In conclusion, I wish to state that I have treated my topic from the

standpoint of a river forecaster, and therefore have made flood warnings of first importance. I judge, however, that from a statistician's point of view, records of low water are as valuable as those of floods.

DISCUSSION.

Mr. L. M. Pindell (Chattanooga, Tenn.). Low-water forecasting is of almost as much importance as high water or flood stages. On the Tennessee River the boatmen watch for and take advantage of every 2-foot rise. Boats drawing over 3 feet of water, or those which are compelled to tie up when the river reaches and falls below the 3-foot stage, seek the best point for shelter, and whenever a rise of 4 to 6 feet is expected the owners order the engineers to get up steam and be ready to move out on the tide. These boats collect up the freight deposited on the river banks and succeed in making a round trip and sometimes more before the river falls to the 3-foot mark. Shallow-draft boats make weekly trips until the river reaches 1 to 1½ feet. Then they have to be exceedingly careful in passing over shoals and rocks in the channel. Practically speaking, the river men consult the river bulletin and forecast more closely in low water than when the river ranges between 7 and 25 feet. The captains instruct the farmers along the river as to the place where they can put their goods and be above the water. As soon as the low-water season approaches the owners of large vessels send them to the lower river trade to save them from becoming stranded upon the banks in shallow water. I am called on after every rain during the low-water season to know about the height the river will attain or how much water can be expected. Forecasting on the Tennessee River is important at all seasons of the year. When navigation is closed to all boats on account of the river being very low, the boatmen watch for the slightest rise and are ready to steam up to make a trip at the proper time, whether day or night. During low water at and below Knoxville the steamboat masters at Chattanooga, Florence, Riverton, Johnsonville, and Paducah always ask the Chattanooga office to telephone or wire them when the rainfall over the headwaters justifies a boating tide of from 5 to 6 feet in the channel. The Tennessee River Navigation Company invariably start their boats to the Hiwassee and Clinch rivers within twenty-four hours after being notified of the expected rise and the time it will reach the various points.

A few years ago—I think it was in the summer of 1898—Capt. J. F. Beaty, of Paducah, wrote me, asking that I notify him by wire when the conditions would justify a rise of 5 to 6 feet at Florence, Ala.; that he had $40,000 worth of ties on the river bank near Riverton and Florence, and that it would take him five days to reach Florence and two days to load. About six weeks after the receipt of the letter heavy rain occurred over the system, and I wired Captain Beaty. He at once got together his crew, started for Florence, loaded, then telegraphed for conditions. The river was then about stationary, but began falling that day. He returned to Riverton, Ala., with his freight safely, and then wrote the observer a letter of thanks for the timely information.

The Tennesse River, with 29 various tributaries, is navigable for over 1,400 miles. The report of the United States Engineer's Office for 1897 gives 80 boats and 365 barges plying the river—19 boats and 84 barges above Chattanooga, 21 boats and 81 barges between Chattanooga and Decatur, and 40 boats and 200 barges between Decatur and

Paducah. The estimated value of property shipped was $2,693,802.85 above Chattanooga, $4,078,227.39 between Chattanooga and Decatur, and $5,572,408.95 between Decatur and Paducah, or a total valuation of $12,344,439.19. These boats also carried, in 1897, 70,624 passengers.

When this data for the Tennessee River is compared with similar data for the Cumberland, Ohio, and Mississippi rivers, and when it is remembered that more than three-fifths of this traffic is carried during the time when the river ranges from 5 to 15 feet, or moderately low water, the importance of low-water forecasting claims the same attention of the United States Weather Bureau as the high-water forecasting. Prof. Charles C. Adams, of the University of Chicago, Chicago, Ill., used the Tennessee River and flood bulletins during the summer and fall of 1900 (and is now receiving them) to enable him to search the upper tributaries for pearls and other specimens for use in the zoological department of the university.

From expressions given by river men, steamboat men, and log men, I know that the low-water forecasts are of much importance to them, for, during low water, a fall or a rise of a few inches even in the Tennessee River and tributaries, if known in time, means a saving of many dollars to the river traffic. The following occurrence will serve as an apt illustration: During the early part of May, 1897, Maj. Dan C. Kingman, of the United States Engineer Corps, stationed at Chattanooga, Tenn., sent the United States towboat *Colbert* to Knoxville; the boat reached Lenoir City, but owing to low water, with the river still falling, was afraid to proceed. Captain Gray telephoned to Knoxville for river information, which was unfavorable; and the *Colbert* remained at Lenoir City nearly two weeks. Major Kingman stated that had the "low-water forecast" been made at the time, he could have saved the Government hundreds of dollars on this trip.

Capts. J. F. Beaty and James Koger, of Paducah, Ky., visit the Chattanooga office whenever in the city, and have repeatedly stated that the low-water forecast was worth thousands of dollars to the lower river traffic, as they could tell within a few inches how deep they could load their boats and barges, and whether they could successfully make the trip. In a talk with Capt. A. J. Gahagan, treasurer of the Loomis & Hart Manufacturing Company, on August 6, 1901, as to his views of the value of low-water forecasting, he dictated the following to his stenographer:

> This service is very valuable to the mill and river people here. In case of the steamboat people, it enables them to tell in advance of reasonably low water to what extent they can load their boats and whether it is safe to estimate that they can make the return trip. In case of the sawmill and lumber interests here, which is a large industry, this advanced information is really invaluable. It is important that we keep our logs in the river: and if we have advanced information as to the probable fall, it enables us always to keep sufficient force employed in keeping logs in the water to save them from getting out on the bank. As the mill interests here largely keep their logs cabled to the bank above the city, if we have notice in advance of the probable turn in the stage of the water, it enables us to anticipate conditions so as to keep a supply dropped down to our local wharf that we can run on at times when we might not be able to get logs to our landings if we waited until we actually needed them. We unhesitatingly say that the low-water forecast is valuable.

I believe better low-water forecasting could be made if the rainfall observers were authorized to telegraph to the center their rainfall whenever it equalled or exceeded one-half an inch, instead of 1 inch as now, because it frequently happens that the river stations report from 0.50 to 0.90 of an inch for one or two days in succession, then over an inch, then less than an inch, making a total average from 3 to 4 inches, while

only one report is received from the rainfall stations, and their total amount for the rain period is unknown until the monthly report is received, when sometimes their totals exceed the totals of the river stations for the same period, but under their instructions could not send the amount by telegraph.

The high stages over the extreme headwaters during May, 1901, which produced great loss and damage over the French Broad and Holston rivers and at Knoxville is a striking example of high water resulting from several daily rainfalls of less than 1 inch. In my opinion, the instructions to the rainfall observers should be changed at once. Another improvement could be made by making Charleston, Tenn., a full river station for the entire year. I receive no information on the south side of the river below Knoxville, Tenn., from May 1 to October 31. The Hiwassee River is a rapid rising and falling stream, and the stage at Charleston is called for during these months by river men and officials from other departments of the United States Government.

I was informed by the river observer that in 1900, when the United States Weather Bureau work closed on April 31, Prof. B. M. Hall, of the United States Geological Survey, Atlanta, Ga., employed him to make daily river readings from May 1 to October 31, at $5 per month. This station if in operation during the low-water months would be of immense importance to the river interests and a great assistance to the forecaster. The improvements by the Government during the past fifteen years have increased the traffic on the Tennessee River, especially in low water, and while the low-water forecast seven years ago was unnecessary, now it is an absolute necessity. It is estimated that within the next two or three years, with proper river appropriations, the improvements now in progress will be completed, the remaining obstructions will be removed, and a low-water stage of 3 feet will be maintained on the Tennessee River during the entire year, making it navigable at all times; then the low-water forecasting will become of greater importance than it is now.

WEATHER FORECASTS AND THE PUBLIC.

By Mr. H. B. Boyer, *Savannah, Ga.*

I am thoroughly satisfied that in the great majority of cases the forecasts are criticised on insufficient grounds, attributable to a misunderstanding or ignorance of the rules of verification by which we are guided in forecasting. This is the point I desire to bring out. The public should be made conversant with what is meant when fair, rain, colder, warmer, cold wave, etc., are forecast. The rules of verification adopted by the Bureau are probably the best that can be devised to meet the present stage of our development; but outside the Bureau these rules are not known, and as each individual has his own conception of what does and what does not verify a forecast, thereon rests the foundation for unfavorable comment. With us a "fair" day means a day without rain, or even with rain if not in excess of a certain small amount, whereas the public, when the term "fair" is used, expect a day not only without rain, but with more or less sunshine; they can not reconcile the words "fair" and "cloudy." I have frequently been prodded with "Is this what you call fair?" on a cloudy day for which "fair" had been forecast. When this has happened I have always taken considerable pains in explaining to my

questioner. To be sure, the terms "partly cloudy" and "cloudy" are used, but they are employed in a way descriptive of the expected conditions, and have no influence on the verification. When "partly cloudy" and "cloudy" are used in a forecast, a failure results, in popular opinion, should those particular conditions not appear. As it is with the general weather characteristics, so it is with temperature. Our rules of verification call for different temperature changes in different months. This the public do not know, and the Bureau suffers as a result. I have found that with many a cold wave signifies a decline in temperature to or below freezing, the amount of fall not being considered; therefore a fall in temperature to freezing without a cold-wave warning is a forecast not verified, even should the absolute temperature decrease be but 5° or 10°. Again, I have noted that erroneous ideas as to the daily weather flags are quite common, not so much as to the meaning of the flags as to the period involved. It can be readily perceived how such mistaken beliefs work an injury to the Bureau.

While the first and most important duty of the Weather Bureau is the forecasting of severe storms, tropical hurricanes, cold waves, and frosts, it should be borne in mind that these conditions are comparatively infrequent, whereas the daily weather forecasts, meeting the public eye on every hand and at all times, are assuredly the most potent agency by which a community judges our efficiency. I am of the opinion that the Bureau, in justice to itself and the public, should strenuously persevere along its present educational lines; but while in pursuit of the larger plans it is well that the details be not overlooked, otherwise we must suffer through faulty interpretation. As I understand it, the present campaign of education has for its principal object the recognition of meteorology as a distinct science and its general admission into the school curriculum. Were these objects attained there would result a smoother path for the service, since the public, then looking at the subject intelligently, would see more clearly the end toward which we are working and be more lenient when viewing our 18 per cent of failures. But in the meantime an effort should be made to correct popular errors in respect to the import of the terms used in the several forecasts, or else adjust our rules to popular requirements.

VALUE OF THE DEW POINT IN FORECASTING WEATHER UNDER CERTAIN CONDITIONS.

By Mr. PETER WOOD, *Pittsburg, Pa.*

[Read by title.]

One morning in April last, after the observation had been completed. it was noticed that the dew point was much lower than usual, so much so as to attract the writer's attention with more than passing interest.

It was found by comparing the dew point with the air temperature that the latter could contain many grains more to the cubic foot before the dew point would be reached; therefore the temperature of the air must be reduced many degrees before condensation could take place. The Central Office and local forecasts both were for rain, and it was noticed that the rain failed; then it was with renewed interest that the writer began to apply in doubtful cases the dew point as an aid in forecasting.

From the 17th to the 24th of this month for local forecasting it seemed to work very successfully.

To illustrate more precisely, take this morning's observation. The air temperature showed 8.374 grains of water vapor to the cubic foot and the dew point showed 7.480 grains. If the air temperature should drop 3.5 degrees condensation would occur. It did drop 16 degrees in about ten minutes, and 0.95 of an inch of rain was the result. The conditions for this morning were expected to be cooler and less humid, because rain had fallen in the evening and night; but, instead, there was more moisture and at the same time the temperature was expected to drop some, but it did not do so until the excessive moisture had been liberated. Of course this last case would not be of any value for a thirty-six hour forecast, but it showed that the humidity had increased instead of diminishing.

Now, the point is, with a chart of reliable dew-point data and the twenty-four hour changes, would it not be a help to the forecaster?

I know the subject is not new, but that does not necessarily prove it unworthy of further attention.

THE DOUBLE OBSERVATION AS A MEANS OF IMPROVING FORECASTS.

By Mr. Lee A. Denson, *Meridian, Miss.*

[Read by title.]

After years of close attention to the charts, reviewing disturbances in almost every conceivable position and form, I am led to the conclusion that the forecaster in many instances, no matter how clear his insight may be, fails in his deductions through the lack of clear, exact, precise knowledge of the latest change in the conditions. Is it not the irregularities, the variations in energy, velocity, direction, and general movement of the areas of low and high pressure, the sudden slowing up or the rapid increase of speed that brings consternation to the forecaster, weakening confidence in himself and cutting down the percentage of his nearly perfect deductions under average conditions? If so, how better can we overcome these irregularities than by placing before him complete, precise knowledge through the means of double (6 a. m.–8 a. m., and, if necessary, 6 p. m.–8 p. m.) observations?

This could be accomplished with very little extra labor, now that the stations are well provided with self-recording instruments.

What additional information will it give the forecaster? Well, let us see. With one additional word alone in cipher, carrying pressure and temperature at 6 a. m., will he not be able to observe at a glance the rate of movement compared with the average of the past twelve or twenty-four hours, as the case may be; will he not be able to observe that the center of a disturbance deviates or not from the average path of the past twenty-four hours, and so obtain the latest direction; will he not be able to observe with more exactitude the relation of formation, and will he not be able to observe its waning or increasing energy? All of these latest phases can be graphically pictured on a single chart with colored pencils; red and green, for instance, for the isobars, and yellow and blue for the isotherms, of the 6 a. m. and 8 a. m. readings.

There are several ways in which the information might be enci-

phered. The following is suggested because it affords a means of sending the pressure change to the nearest hundredth of an inch: Let the word denoting change in pressure since and the temperature at 6 a. m. be the first of the cipher words. Let the first syllable represent change in pressure and the second the temperature. Let the vowels u and a in first syllable show no change and a rise of 0.10, respectively; and, in like manner, e and i for a fall. Now, let the proper consonants, b, d, f, etc., signifying 1, 2, 3, precede these vowels, and we have the first syllable representing each hundredth of change from 0 to 0.19. In the second syllable encipher the 6 a. m. temperature. For example: A rise of 0.05 of an inch and temperature of 70, use the word "Mudrug;" a rise of 0.15 and same temperature, "Maryland;" and likewise, for a fall of 0.05 and same temperature, use the word "Merry," and for a fall of 0.15 and temperature of 70, the word "Miry."

The forecaster has no direct means of getting at the exact variation from the average, and it is for the purpose of developing these irregularities and bringing them clearly to mind that this suggestion is made. It seems to me that we must try some such method if we ever hope to obtain a marked improvement in forecasting.

SUBSTITUTION OF ACETYLENE GAS FOR OIL IN STORM-WARNING LANTERNS.

By Mr. H. W. Richardson, *Duluth.*

[Read by title.]

The recent introduction of high-power lanterns and steel towers marks a distinct epoch in the matter of storm-warning displays, greatly improving that part of the Weather Bureau service. But there is still room for improvement as regards visibility of lights.

At present either oil or electricity is used, depending upon circumstances. Electricity undoubtedly gives the greatest satisfaction, but it is quite costly and not always obtainable.

The distance of visibility depends upon various conditions, viz, the accuracy of the reflecting and the refracting surfaces of the lens, the quality, candlepower, and elevation of light, and the condition of the atmosphere.

A lens in which each prism is ground true and the flame of light placed in the proper focal plane will give a light 50 per cent stronger than with the same candlepower of flame in an ordinary pressed or cast lens. In the strongest lights used by the United States Light-House Establishment on the Great Lakes the burner gives only 163 candlepower, while the beam transmitted by the lens measured over 20,000 candlepower, which shows what an important part the lens plays in this matter. But such powerful lenses are not really practicable for Weather Bureau displays on account of great cost and because of possible interference with range lights, and when a high candlepower is obtained the pressed or cast lens will serve the purpose.

Neither electricity nor oil furnishes a pure white light. The former is, as stated, costly, and the latter, with each increase in candlepower, is accompanied by a corresponding increase in degree of heat. The burners in the new oil lanterns are a trifle over 16 candlepower, and in the old-style lanterns it is probably only half as much.

One of the purest white lights known to science is that obtained

from the gas, acetylene. This gas was discovered in the year 1836, but up to the period 1892–1895 its manufacture was costly and restricted to experimental production in laboratories. In the period just mentioned a cheap method of manufacturing calcium carbide was discovered. The combination of this carbide with water decomposes the latter, forming acetylene gas and slaked lime. The cheapness of manufacture has resulted in a wonderful increase in the commercial use of this gas, especially as regards the lighting of residences, places of business, bicycle lamps, etc., the most satisfactory generators being those in which the gas is consumed as rapidly as made.

Interesting experiments have lately been conducted by the United States and the German Governments with acetylene gas as applied to the illumination of light-houses and buoys. The United States Light-House Establishment finds that acetylene is not easily compressible and its use not practicable where it is to be burned for any great length of time without attention, say five to thirty days, particularly in the case of isolated buoys. This defect is on account of the accumulation of unconsumed impurities in the burners, which tend in time to extinguish the light. Such, however, is not the case during twelve to thirty-six hour periods of illumination when the tips or burners can receive attention. This trouble can be almost altogether eliminated by inserting a small amount of absorbent cotton in the gas passage, the cotton acting as a filter. The steadiness of flame depends upon the regularity of flow and evenness of water feed over the surface of the carbide. The process of transformation also heats the gas somewhat, but this would, if anything, be an advantage during cold months, as it would tend to keep the water from freezing. This object can also be accomplished by using a dilute brine in place of clean water, but the use of brine would result in diminishing the intensity of light in proportion to the strength of the brine. Acetylene light also gives off much less heat than ordinary illuminating gas. In a flat-wick oil burner the flame must be nearly four times as large to produce the same candlepower as acetylene, the illuminating power of the latter being more than double that of any other portable light or that of coal gas.

In a lens capable of holding a 52-candlepower lamp the United States Light-House experimenter found that a group of 5 acetylene three-quarter-foot burners gave 320 candlepower, the charge being 6 pounds of carbide, which made about 48 cubic feet of gas, burning nearly thirteen hours. In another experiment, with the same amount of gas, 4 one-half-foot burners gave 32 candlepower each for a period of twenty-four hours. The gas gave off practically no odor nor smoke and very little heat while burning. On the other hand the same 52-candlepower oil lamp caused the lens to become very hot. In the case of the cluster of 5 acetylene burners the lens was only slightly warm.

The cost of commercial carbide, in large quantities, is about 3 cents per pound. One pound of carbide produces a little over 5 cubic feet of gas and will run a 16-candlepower one-quarter-foot burner twenty hours. A 16-candlepower oil burner, in operation twenty hours, using about one-half gill per hour of 12-cent oil, costs 3.43 cents, so it will be seen that the cost of oil is slightly greater than acetylene, the latter also possessing many other advantages.

In experiments conducted by the writer, specially constructed 3-burner and 1-burner lamps were used. Tests as to actual candlepower were not possible at the time. The 3-burner lamp contained a

charge of between one-half and two-thirds of a pound of carbide, burning twelve hours at a cost much less than that of electricity and slightly less than oil, producing a very brilliant light. Extra lanterns (white and red, marine) being available, displays were made as near as possible and in conjunction with the new-style lanterns in regular use. It was found that the light of this 3-burner lamp greatly exceeded that of the two 32-candlepower electric globes in the white lantern and slightly exceeded the light given off by the four 32-candlepower globes in the red lantern, comparison being made between the two white lanterns and the two red lanterns. In the same kind of test, using oil and acetylene, the latter gave a vastly superior light.

The 1-burner lamp gave, proportionately, a finer and more satisfactory light than the rather crudely constructed 3-burner lamp, the former being made by a gentleman in Duluth for use on his bicycle. It is not intended that this lamp shall be placed on the market, but the maker has very kindly offered to allow the Weather Bureau (if so desired) to copy the general plan or design free of charge. It contains a number of ingenious and useful features not found in other lamps of this character, greatly increasing its efficiency, giving a beautifully clear, white, penetrating, cheap light that will not jar out or blow out. It is perfectly safe, easily handled, and quickly charged. Such a lamp, enlarged and modified in arrangement, would, it is believed, serve the purposes of the Weather Bureau in the highest sense. It certainly could be used to advantage in place of oil, and to replace electricity where the latter is unusually costly.

The writer is under many obligations to Mr. R. E. Wrege, superintendent, Light-House Service, Milwaukee, for information regarding acetylene as tested by his Bureau, and to Capt. John Flynn, Duluth, for apparatus furnished in connection with experiments.

VERIFICATION OF WEATHER FORECASTS.

By Mr. J. B. Marbury, *Atlanta, Ga.*

[Read by title.]

The weather and its changes have been of interest to man from the remotest ages, and there has probably never been a time since his advent upon earth that he has not felt more or less interest in its changes from day to day or season to season. This being the case, there has probably always existed some form of weather forecasting. Prior to the flood there lived wise men who posed as weather prophets, the most noted of whom was, possibly, Noah, who foretold with such wonderful precision the heavy rains which floated his ark for so many long dreary days.

Ancient writers dwelt much on weather phenomena, but their limited knowledge of the subject was based chiefly on the collection of popular weather prognostics with reference to the flight of birds, movement of animals, appearance of the heavens, etc. Certain appearances of the sky were premonitions of certain atmospheric changes; the same was true in relation to the actions of animals. But very little real advance in weather forecasting was made until within the last century. If time permitted, an unbroken chain might be traced from the embryonic stage to the present, showing the gradual evolution from ignorance and superstition to our own age and time, when nearly every civilized nation of the world is maintaining a

weather service of some kind and issuing forecasts of the weather of some sort.

The daily prediction of the probable weather conditions is by far the most practical application of the science of the weather. There is scarcely a calling in life that is not to a greater or less degree affected by the atmospheric changes. Commerce on our great waterways is greatly benefited by the storm warnings; perishable goods in transportation are often saved by the warning of a cold wave; the farmer, with his fields of ripening grain, is told when to reap. Much property and many lives are often saved by timely warnings of approaching floods in our important streams. At critical seasons when frost is probable forecasts of its approach are of great benefit to truckers, cotton and tobacco growers. During the period of seeding it is important to know when showers or sunshine are to be expected. These are but a few of the many and varied branches of our Bureau. It therefore seems of paramount importance that to fully meet all requirements the forecaster should have only the public welfare in mind when making his forecasts of the weather to be expected during periods covered by his predictions. He should not allow rules of verification to influence his decision, but say just what the chart seems to reveal to him. He should cast aside the fact that the verification of his forecast is decided by a circle 8 inches in diameter—the rain gage—and remember that there is a vast area to be affected, and while he may not make a high percentage, large property interests may be greatly benefited by the warnings issued to the public. This is especially true during the summer months, when local showers are predicted. It frequently happens that the observer while sitting at his office window can count several showers within a radius of 1 mile of his station, while not a drop falls in his gage. So far as the public is concerned his forecast was correct, while his marking by the official verifier will be zero.

For numerous reasons it seems absolutely necessary that all forecasts should be verified, but it is very difficult to determine just what method of verification gives the most satisfactory results. So far all rules used seem to be more or less defective, and fail to accomplish the desired results. Should we take any special class of predictions and compare them with subsequent conditions on the basis that the forecaster is entitled to 100 per cent whenever the phenomenon predicted follows, and to zero when the subsequent weather fails to coincide with that forecast, we do seem to reach the desired end; but even this does not always give an accurate test as to the ability of the forecaster. For example, there are certain months when the weather is remarkably uniform and settled, the changes very slow and gradual, easy to be foreseen, while at other times changes are frequent and abrupt. There are also sections of our country where the weather repeats itself from day to day for protracted periods. During certain months a constant forecast for fair weather and stationary temperature would be verified 95 per cent, and a prediction of rain would give almost the same result another portion of the year. It would, therefore, certainly not be justice to compare a forecast made under those conditions with those made at points where the weather is as erratic as, say, in New England or in many of the States east of the Mississippi. There are some sections having seasons wet and dry so well defined that about the only failure would be just on the turn from wet to dry, or vice versa. One might predict fair for half the year and rain for the remainder, and make 90 per cent or more, while the same official would probably not make 80 per cent in a different locality.

A forecast for warmer or colder, according to the present method of verification, is far from satisfactory, and is not at all in sympathy with the ideas of the public. Warmer or colder is understood by the layman to mean that the day will be warmer or colder, and not that there will be a certain number of degrees difference in the temperature at the time of two observations taken twenty-four hours apart. It frequently happens that a forecast for warmer is followed by a day with a prevailing temperature lower than on the preceding day, but just at the time of the observation it may be a few degrees higher than at the same hour the preceding day, thus verifying a forecast which is looked upon by the public as a failure. A forecast for warmer should mean that the temperature during the period forecast for will go higher than that on the day the prediction is issued, and the same rule for colder. To more nearly coincide with the popular impression it seems to me advisable to use the readings of the maximum and minimum instruments rather than the temperature at the a. m. or p. m. observations.

FORECASTING FOR RIVERS OF SMALL DRAINAGE AREA, ESPECIALLY THOSE OF NORTH CAROLINA.

By Mr. C. F. von Herrmann, *Raleigh, N. C.*

[Read by title.]

Recent developments in the possibilities of the electrical transmission of power have contributed largely to the wonderful industrial progress witnessed during the past decade, and have awakened special interest in water powers, the cheapest and most abundant source of energy. Information of all kinds concerning rivers has been eagerly sought, and investigations in regard to the flow of streams as regulated by varying conditions, the probable elements of danger to machinery and buildings by destructive freshets, or of loss by protracted periods of low water, have been carried on extensively by State or national authorities.

The observation of river stages and the issue of flood warnings became a natural part of the duties of the Weather Bureau from its beginning, and since the reorganization of the river and flood service, in 1893, the importance of the work has greatly increased. While the saving of life and property by successful warnings of dangerous floods is often very large and will always chiefly attract public attention and favorable comment, a truer measure of the value of the river work will be found in the variety of interests constantly served by the information collected and published. This service is fully appreciated by all people whose business is directly connected with rivers, as steamship and transportation companies, levee boards, boatmen and lumbermen, farmers whose crops are liable to injury or destruction by floods, and especially by hydraulic engineers and manufacturers using water power, to whom a knowledge of extreme river stages and daily fluctuations is of the utmost importance.

The work of the river service is now assigned to single officials, who have the sole responsibility for the successful conduct of affairs in their respective districts. The official in charge of a river center must observe the fluctuations of the rivers assigned to him and issue daily forecasts or flood warnings when required, and he thus has the opportunity to carry on valuable investigations into the peculiarities

of the rivers within his jurisdiction. The flood service of the Weather Bureau covers all of the larger rivers of the great Mississippi Valley and the Pacific coast region, as well as many smaller streams entering the Atlantic or the Gulf of Mexico. There is accordingly extremely wide dissimilarity in the size and character of the various rivers for which forecasts are made. In a vast river system like that of the Mississippi, or even any of its larger tributaries, where the drainage area is so extensive as to embrace different climates and immense variety in topographical features, the amount of discharge is in great measure independent of local influences, and either remains tolerably uniform or the variations are periodic. In smaller rivers, such as those of the South Atlantic slope, the basins lie largely in a region having uniform features of climate, and the quantity of discharge is regulated by local rainfall.

The problem of successful forecasting for small rivers presents great difficulties, since the physiographic conditions controlling flow must necessarily have a more direct influence over a small than over a large catchment basin. Heavy rains easily become general over a small area, while the topography of the region, the nature of the soil and soil covering, the contour of the stream, etc., even if tending to diminish the run off, can not act quickly enough to materially lessen the violence of the freshets. The rules for flood forecasting are still largely empirical; but the experience gained from a large river will certainly fail if applied to a small one. The specific differences in practical forecasting may be shown by the following illustration: The river forecast official at Cincinnati will hardly find it necessary to take account of the geological formations through which the Ohio has cut its channel, nor of minor features of topography, for the size of the river itself indicates that most of the variations originally resulting from such causes have been obliterated long ago. In general, then, forecasts for definite stages at Cincinnati will depend almost exclusively on the actual stages recorded at river stations above that point, and floods under all but the most exceptional circumstances will not be predicted from excessive rainfall alone. This is true for every important river in the Mississippi Valley. Generally there will be ample time to issue warnings well in advance, since, for instance, the crest of a flood wave requires twenty-three days to pass from Pittsburg to the mouth of the Mississippi.

Very different conditions prevail in the districts of the middle and south Atlantic States. Three gauge stations are located on the Roanoke, the largest river of southern Virginia and North Carolina, which are separated by distances of about 60 miles. But it is possible for the Roanoke to rise from relatively low stages so rapidly that in twenty-four hours the danger lines at all three stations are passed simultaneously.[a] It is necessary in some cases to issue forecasts for a river with only one gauge station on its lower course, which plainly involves still greater difficulties. The official at Raleigh would certainly not dare to predict for the Cape Fear River at Fayetteville, N. C., a rise of 40 feet in forty-eight hours without possessing a thorough familiarity with the peculiar configuration of the river which makes such fluctuations possible.[b] Changes of 30 feet in twenty-four hours are not uncommon in some of the rivers of the south Atlantic coast,

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[a] This remarkable phenomenon occurred on July 9, 1896, and again on May 23, 1901.

[b] Stages on Cape Fear River at Fayetteville: May 22 (forecast issued), 14 feet; May 23, 48 feet; May 24, 58.5 feet.

and the time required for the flood wave to reach the sea is very short. Under such circumstances river forecasts must depend largely on the precipitation reported and on the estimated rise that may be expected from a given amount, and it is necessary to investigate carefully the influence of all the physiographic and climatic factors in increasing or diminishing the run off in order to achieve a reasonable measure of success.

For convenience of treatment the physical conditions of the drainage basin will be considered in the following order: 1, geological conditions, such as the influence of geological structure, the permeability or impermeability of rocks, and the peculiarities resulting from different rates of erosion through hard or soft strata; 2, topographical features, the size and shape of the drainage basin, the character of its surface, and the form of the river channel itself; and, lastly, 3, the climatic factors will require somewhat extended examination, such as the influence of pressure, temperature, winds, and rainfall, especially the latter, as modified by topography and location, with reference to the prevailing track of cyclones. Necessarily only brief and general outlines can be presented here, and while the facts apply closely to the rivers of North Carolina, they will probably hold true for most of the streams of the southeastern United States.

I.—GEOLOGICAL CONDITIONS AFFECTING THE FLOW OF RIVERS.

In order to trace the effect of geological structures which modify the flow of rivers, especially during high waters, it will be necessary to sketch quite briefly the general character of the region to which these remarks particularly apply.[a] The States of the Atlantic slope occupy portions of three well-defined geological provinces, known as the coastal plain, the Piedmont plateau, and the Appalachian Mountain region. The Coastal plain borders the Atlantic ocean, extending inland from 100 to 200 miles, and comprises a region recently and but slightly elevated above sea level. It is built up of unconsolidated sands, gravels, and loams, in horizontal layers, through which the rivers flow in tortuous courses to the sounds or directly to the sea. The Piedmont plateau region occupies the territory between the Coastal plain and the mountains, and extends from Alabama to New Jersey. Along its western border the Piedmont plateau is somewhat mountainous, but it is low and rolling near the Coastal plain. This region includes the largest portion of the drainage areas of the Southern rivers. The geological formations here cross the States obliquely, parallel with the mountains, and form a succession of belts of crystalline rocks, sharply upturned, across the edges of which the rivers have cut their channels. After the process of erosion had continued for a long period of time a further elevation of this region took place, increasing the slope, while in the course of ages the soil attained considerable depth, varying from 10 to 100 feet, chiefly by the decomposition of rocks in place. The mountain region comprises the Appalachian system from Alabama to New York, and contains in western North Carolina the highest elevations in the United States east of the Rocky mountains.

The course of a river flowing through these regions may be divided into three parts:[b] (1) The mountain track, where it takes its rise as a

[a] For details see Bulletin No. 8, North Carolina geological survey, 1899.
[b] Modified after Geike, Archibald: Text-Book of Geology, 3d edition, p. 375.

mere brook, and, fed by innumerable similar torrents, dashes rapidly down the steep sides of the mountains in endless cascades and growing every moment in volume until it enters lower ground. (2) The valley track, where, now flowing through lower hills or undulations, the stream is found at one time in a wide, fertile valley, then in a narrow gorge, perhaps falling into rapids favorable for water powers or expanding into broader channels. Here it receives the largest tributaries and assumes the most varied aspect. (3) The plain track, where the river finally emerges upon broad, low plains, probably in great part composed of alluvial formations deposited by its own waters. Here, in a winding, sluggish course it approaches the sea through tracks of flat meadow or marsh, and finally, amid banks of mud and sand, passes into the great ocean.

It is not possible in a brief space to discuss all the influences of geological formations which are of economic importance; indeed, many of these are too intricate to be estimated practically. Minor geological structures chiefly control the flow of underground waters, and thus become very effective at low stages, replenishing springs and keeping up the supply of water in rivers during prolonged drought. It will be sufficient to point out a few of the grosser features which have been found to require consideration in practical river forecasting:

1. The natural boundary between the Piedmont plateau and the coastal plain is formed by the "fall line," which extends from Richmond, Va., to Macon, Ga. Here is found an outcrop of hard, crystalline schists, more difficult to erode than the strata on either side. The elevation of the fall line above sea level, which is nearly zero at Richmond, varies from 26 feet on the Roanoke at Weldon to 250 feet on the Ocmulgee at Macon. The consequence of this formation is that the rivers have eroded much wider and deeper channels above the fall line, over which they flow in rapids or through narrow gorges, where generally the lower river gages are located. For many rivers the effect of this characteristic geological structure is of the greatest importance. Obviously, during a flood an immense volume of water must collect in the wide and deep channel above the natural barrier at the fall line, which can only escape slowly through the narrow gorge described. The Cape Fear River in Harnett County during high water is several miles wide at many places, while at Fayetteville the entire mass of water must flow through a channel from 150 to 200 feet wide and 60 to 100 feet deep before it can spread out over the low region of the coastal plain. A knowledge of this feature removes the natural surprise one first experiences in finding a river less than 300 miles long with a range of 60 feet so far down in its lower course.

2. The permeability or impermeability of the deeper rocks underlying the soil, as well as the depth and porosity of the soil itself, which will be treated later, have a marked influence on the flow of streams and require the consideration of the student of hydrographic conditions. It is impossible to give general facts, since the subject requires investigation for each river basin, and a few examples of this phase of geological structure must suffice. The chief tributaries of the Cape Fear, the Haw and Deep rivers, flow in Chatham County through a slaty, broken region, thinly covered with soil, which sheds water very rapidly. During summer drought the smaller tributaries in this vicinity become almost dry, indicating by the absence of underground drainage and springs the impermeability of the surface rocks. It has been found that heavy rains between Moncure and Chapel Hill, N. C., increase the suddenness and the range of the freshets in the Cape Fear.

On the other hand, below the fall line, and sometimes extending above it, is found a belt of sand some 30 or 40 miles wide and of varying thickness, sometimes reaching 110 feet, which is generally well covered with forests of long-leaf pine. The tributaries flowing through this region, notably Rockfish Creek, are characterized by a remarkable uniformity of flow. Sand absorbs water almost like a sponge and gives it up gradually; the water absorbed is largely removed from the influence of temperature, evaporation is diminished, and the difference in effect between summer and winter rains disappears. Lumber River, which merges into the Little Pedee in South Carolina, flows entirely through a sandy region of this kind. The rise in the Lumber River measured on the gauge at Fairbluff, N. C., does not exceed $1\frac{1}{2}$ feet in twenty-four hours, and it requires six days for the wave crest to pass from the headwaters to the Great Pedee a few miles above Port Harrelson, S. C.[a]

3. Lakes and other natural storage reservoirs evidently regulate the drainage of the area below their outflow and diminish the danger of floods, and their absence operates unfavorably on the constancy of streams. The latter condition obtains quite generally in the Southern States, though probably counterbalanced somewhat by the extensive forest covering still remaining. In some cases the low elevation of the flood plain and the great width of the river will cause many miles of lowlands to be submerged at comparatively low stages, the accumulated water acting somewhat as a natural reservoir. This feature is characteristic of the Santee, in South Carolina, which requires exceptionally heavy rainfall at upper stations to cause an elevation of the stream of 1 foot in twenty-four hours. However, where the contour of the river is such that the large volume of water must seek its way to the sea through a narrow pass, the duration and danger of floods is immensely increased, as already mentioned.

These illustrations are sufficient to show that the geological structure of the ground, as well as meteorological conditions, as cause of floods, merit the careful attention of the river forecast official.

II.—INFLUENCE OF TOPOGRAPHIC FEATURES.

1. The most important feature of topography, resulting from the original upheaval of the Appalachian chain and subsequent erosion, is the slope or gradient of the land surface, which determines the rate of progress of the flood wave and the time available for the issue of warnings and the removal of property from danger. The steeper the slope the more rapidly does the water of the tributaries enter the main stream and the greater becomes the rate of advance of the flood. The declivity of a basin is usually ascertained by dividing the elevation above sea level of the highest point in the watershed by the length of the river, but more useful results would be obtained by calculating the slope for each portion of the river track. The south Atlantic rivers mostly have a very considerable fall, exceeding in many cases that of the entire Mississippi from its sources to the Gulf, though few of these rivers exceed 300 miles in length. The angle of inclination is greatest, of course, in the mountain track. Western North Carolina is noted for its numerous and beautiful waterfalls. In the valley tract—Piedmont plateau—the gradient of the land surface is still quite large and exceeds that of a navigable stream. It varies from $3\frac{1}{2}$ feet in central North Carolina to over 6 feet per mile farther south. The Piedmont

[a] Weather Bureau Bulletin No. 17, p. 60.

plateau is the region of most available water power and is the home of the manufacturing industries of the South. In the low region of the coastal plain the slope scarcely exceeds 1 to 2 feet to the mile, and the rise of the river during floods diminishes to a few feet.

2. The character of the surface of the catchment basin acts in many different ways on the disposal of the precipitation falling upon it. A shallow soil, overlying an impervious substratum, promotes drainage and prevents the storage of water. A deep, porous soil absorbs water, lessens evaporation, and conserves the water supply while materially diminishing the rapidity with which a given rainfall enters the river or reaches the sea. It is this storage of water by soil and rocks which prevents a river from drying up completely during every summer drought. A clayey soil, while itself able to contain more water than a sandy loam, if saturated, offers great resistance to the entrance of water and increases the run-off. Furthermore, if a river has not cut down its bed to the underlying rock there may be considerable percolation through subterranean fissures.

The soil also acts quite differently in disposing of a heavy rainfall if the season has previously been very dry or very wet; that is, upon the elevation of the ground water depends the proportion of run-off, since the tendency is first to restore the normal elevation of underground water surfaces. The influence of the texture of the soil as modified by tillage will be referred to below.

3. Of the soil covering the two main factors are forests and cultivated land. The action of forests is very complicated, and notwithstanding much study devoted to the subject it is not yet well understood. Excluding some cases where peculiar local conditions obtain, it appears probable that forests have no power to increase the rainfall and their destruction will not diminish it. Forests act entirely as regulators of flow by diminishing the speed with which the raindrops reach the ground and by increasing subdrainage through the removal of ground water by transpiration, in both ways diminishing the quantity of water flowing directly to the streams, especially during summer, though evergreen forests accomplish the same thing in winter. The removal of a forest will not cause more frequent freshets, but will intensify those that do occur, and then only when the deforested area remains untilled. Incidentally the roots of trees and shrubs bind the soil together and prevent the washing of the land into gullies by every heavy rain.

Forests lessen evaporation in the shade of their foliage by reason of diminished insolation, higher humidity, and interrupted wind movement, but at the same time the amount of vapor which they give to the air by transpiration is very large. A forest of oaks will consume more than a quarter of the annual rainfall during the growing season. The vapor thus transpired is lifted from the ground waters which, under similar circumstances, will be found lower under a forest than under cultivated fields. To this extent, therefore, forests do not conserve the supply of moisture, but consume it, as proved by the fact that crops can not be grown successfully near rows of trees.

4. The soil of a well-tilled field, especially where deep or subsoil plowing is practiced, as regards texture is in condition to absorb a large amount of rainfall. When the surface is plowed shortly after a rain the capillary tubes are broken and evaporation prevented by the earth mulch formed. The action of cultivated fields is so marked that the effect must be estimated and allowed for, as it accounts to a much larger extent than usually supposed for the difference in causing floods

of a given rainfall in summer and winter, though temperature here plays the important rôle.

If possible, therefore, for every river basin the extent of the forest covering, the amount of cultivated land, and the proportion of deforested area that remains unimproved should be accurately known and mapped. In the South Atlantic States it is probable that forests still occupy from 50 to 70 per cent of the total area.

III.—CLIMATIC OR METEOROLOGICAL CONDITIONS.

Some knowledge of meteorology and ability to make weather predictions are prerequisites to success in river forecasting. Rivers are the product of the normal rainfall, floods of an excess of the normal, and in considering the influence of the meteorological factors, the element of precipitation and the causes which modify or control it must receive the largest share of attention. For the purpose of a complete view of the subject, however, it it desirable to take some account of the other elements of pressure, temperature, and wind, although it is difficult to estimate their effect for practical purposes. It is not intended to give specific data in regard to climate beyond what is essential for a general outline.

1. *Pressure.*—It is said that barometric changes exert an influence on the level of ground waters, as well as upon the rate of discharge of springs. Diminished pressure causes a rise in the water level in wells and increases the flow of springs.[a]

2. *Temperature.*—Temperature acts upon the water supply of rivers and the manner in which the rainfall reaches them in two ways, by its influence on evaporation, and, when below 32° F., by rendering the soil impervious by freezing; the one cause diminishing, the other greatly facilitating the run-off. Since the capacity of space for water vapor is greater the higher the temperature, evaporation increases with insolation, and is largest in summer and least in winter, but varies also with the relative amount of land and water surface, and on the character of the soil and the vegetation covering it. Measurements of the annual evaporation for a given region are important. The annual evaporation for the south Atlantic states averages approximately 40 inches, as determined by experiments made with a Piche evaporometer in the ordinary instrument shelter, a figure probably too high to represent natural conditions. Assuming that a certain portion of the rainfall for each month is discharged by a stream, then the amount actually so discharged will vary on account of evaporation from 20 or 30 per cent in summer to 70 to 80 per cent in winter. The flow of a river decreases as the temperature rises, and generally so, notwithstanding a larger rainfall during the summer months in the region under discussion.

Frozen ground is very impervious to water, and the run-off in winter is rapid and complete. However, in the South the ground is so rarely frozen for any great length of time even in midwinter that this condition demands less attention than is necessary in the North.

The freezing of the rivers themselves and the formation of ice gorges which frequently become the cause of dangerous floods in colder regions are so rare here that they may be said never to constitute a factor in the problem. Ice gorges form only in the smaller rivers of the mountain section. During the severe winters of 1857, 1886, 1893,

[a] Weather Bureau Bulletin No. 5.

and 1895, however, many of the rivers and even the sounds of North Carolina were frozen with ice a few inches thick for brief periods.

3. *Winds.*—As compared with quiet air, brisk wind movement increases evaporation very greatly. At a velocity of 5 miles the evaporation from a Piche evaporometer was two times that from one in quiet air, and at 30 miles it was six times as much.[a] Winds from the westerly quadrants are more effective than those from the east, on account of their lower dew-point. In some instances on-shore winds during the passage of tropical storms have piled up high tides in estuaries at the moment of flood stages in the rivers with disastrous results. The rain-bearing winds on the south Atlantic slope are those from the south, east, and northeast. On the eastern and southern slopes of the Blue Ridge mountains very heavy precipitation has occurred apparently entirely as the result of winds blowing directly against the mountains, forcing upward masses of vapor-laden air from the ocean and producing condensation in accordance with well-known laws. A remarkable instance of this kind occurred in western North Carolina September, 1898, causing a tremendous downpour of water over the upper basins of the Yadkin and Catawba rivers.

IV.—PRECIPITATION.

In regard to the most important element of all, precipitation, the topics requiring consideration are the distribution throughout the year as shown by the monthly normals, the frequency and duration of excessive rains, the storage of unmelted snow during winter, and, lastly, the special types of weather most favorable for heavy rains.

The south Atlantic States belong to that part of the United States having the largest precipitation, the center of this region of precipitation lying near the mouth of the Mississippi River. The annual is least in Virginia (41 inches) and increases to southern Alabama. North Carolina has the very large annual of 52 inches. Throughout the entire section a larger annual rainfall is found along the coast and in the mountain region than over the Piedmont plateau. There are localities on the southern slope of the Blue Ridge which have an annual not exceeded anywhere in the United States except on the coast of Washington or Oregon. At some points an annual precipitation exceeding 100 inches has been measured.

The abundant and relative uniformity in distribution of the rainfall throughout the year should indicate a steady supply of water in the rivers and the possibility of floods at any season of the year. But in fact the flow of rivers in this region is extremely variable and the freshets frequent and violent, showing the necessity of accurate investigation of all the features of discharge. The greatest monthly rainfall occurs in July and August, and the least in October, with a secondary minimum in April. The rivers of the entire region, however, maintain their highest average stages in February and March, and decline during the latter half of the year, attaining the minimum flow in September.

In respect to the frequency of heavy rains the southern States rank very high. Excessive rains of 6 inches in twenty-four hours have occurred at one or more stations in North Carolina in every month of the year. There seems to be no law in the distribution of excessive rainfalls, though usually they appear to have the nature of local

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[a] Monthly Weather Review, September, 1888.

cloudbursts within general heavy rain areas. Of more importance than the intensity of the rainfall is the question whether the rain is general over the entire catchment basin or is due to local convectional currents. Everyone is familiar with the difference in this regard between winter and summer rains, the latter consisting largely of local thunderstorms; and it is then extremely important to know whether rainfall is general in character, which can only be done by keeping close watch of the daily weather maps.

The storage of unmelted snow in the Appalachian mountain region south of Virginia is usually so small that melting snow never constitutes a factor in causing floods. The average snowfall south of Virginia does not reach 6 inches at the highest elevations; and periods of mild weather in winter are so frequent that snow rarely remains unmelted for more than a week at a time. There are therefore no spring floods, as such, in any of the rivers of the South. In February, 1899, with the ground frozen and covered with unmelted snow to an average depth of 15 inches in central and eastern North Carolina, a moderate rainfall and thaw caused dangerous floods in the Cape Fear, but such an occurrence takes place perhaps once in a quarter of a century.

The early recognition of the approach of the type of storm most favorable for the production of general and heavy rains over a river district will forewarn the forecast official and enable him to anticipate its probable consequences. The south Atlantic States are not within the regular track of storms, but the southward movement of the prevailing track in late winter and early spring brings the region under the influence of storms at the season of the year when most other causes contribute to make the run-off of rivers greatest. In general the heaviest rainfall is associated with depressions which move from the west Gulf coast around the lower end of the Allegheny mountains before curving northward. The actual depth of the barometric depression is not its most important feature, but the rate of movement. Therefore, floods are more probable when such a storm is opposed in its forward motion by the presence of an area of high barometer over the north Atlantic States. Frequently the most disastrous type is the indefinite low area which seems to divide in crossing the mountains from northern Georgia, the elevation of the land surface in the region appearing to assist the normal cyclonic functions in the production of heavy rains. Storms which first appear on the south Atlantic coast, coming from the ocean to enter the land, quite frequently lose their distinctive formation and resolve themselves into general rains of considerable duration, which cause floods when the area has drifted to the upper river basins. Tropical cyclones occur in August, September, and October at a time when the rivers are low, the conditions diminishing run-off at a maximum, and on account of their rapid movement are less to be feared, aside from the damage caused by wind and tide, than the more slowly moving depressions.

CONCLUSION.

The run-off of a river during floods is extremely variable, and the modifying conditions are very numerous and intricate in their effects, so that with our present knowledge the action of many of the factors above enumerated can not be estimated numerically. Figures given for the ratio of discharge to rainfall are of doubtful utility for river forecasting, although recent measurements of discharge are vastly more accurate than the older estimates. In the Ohio basin one-fourth

of the rainfall is discharged; in the Missouri only one-seventh; in the St. Francis River nine-tenths.[a] The Cape Fear River during the floods of February or March certainly discharges as much as 90 per cent of the rainfall over its basin. To establish specific rules the forecaster must fix: (1) the gage relations of all stations on a river; (2) the rate of movement of the crest of the flood wave between stations; (3) the rainfall relation or stage which a given number of inches of rainfall in twenty-four, forty-eight, or seventy-two hours will cause at the verifying station. The publication of all the rules which have been established would be of great interest. Only a careful consideration of all the factors enumerated, a knowledge of the history of past floods, and some practical experience will enable the forecast official to make rules for forecasting in his district which will lead to success.

SHOULD THE TEMPERATURE BE VERIFIED BY MAXIMUM AND MINIMUM READINGS?

By Mr. P. F. Lyons, *St. Paul, Minn.*

[Read by title.]

The public in general considers that a day or a night is warmer or colder than a preceding day or night not by a comparison of the temperature at certain stated hours, but on the basis of whether it is warmer or colder at any time of the day or the night than it was at any time of the previous day or night, or, briefly, by the difference between the maximum or minimum temperatures for each successive day or night. However, the public is usually indifferent and will scarcely notice changes of 8° or more either way, except when the heat or cold goes above or below the limits of comfort, and then it will be impressed with changes of 2° or more, the impression being in proportion to the departure of the temperature above or below said limits. But aside from the public, science, it would seem, should require the most rational basis for determining the question and at the same time be in harmony with the public. In verifying temperature forecasts by the maximum and minimum I consider that science and public opinion will be completely in harmony.

But aside from harmony, the present method of verifying is often adverse to the forecaster. At night and during the cold seasons the difference is not much, but during the season when thunderstorms are common, I find in my experience, that it is considerable, for a warm day may succeed a much warmer or a much cooler one. The forecaster may forecast stationary or much higher temperature, according as the conditions on the map may warrant. The stationary or much higher temperature may follow just as he expected, but toward evening a thunderstorm may occur and cause a sudden fall of 8° to 16° in temperature, and just about the time for the evening observation (such occurrences are not so very rare) he would lose his forecast not only for stationary, but higher temperature, too; yet to the public the day was either as hot or much hotter than the preceding one.

The 24th of July, 1901, recorded as the hottest day at St. Paul, is offered as an instance. For that day the unprecedented maximum temperature was 104°, while at 8 p. m. it was only 85°. It was 96.5° at 8 p. m. of the preceding day, but the maximum was only 101°. The forecast for the 24th was "slight change in temperature." Imme-

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[a] Physics and Hydraulics of the Mississippi River, 1861.

ediately after the registration of 104°, which was about 4.20 p. m., there came a thunderstorm and wind rush, which resulted in a fall of 30° by 6 p. m. After that there was a gradual rise, but not enough to justify the forecast, since colder weather would be the only forecast that could be justified under the circumstances, notwithstanding the public were forcibly convinced that it was the warmest day on record.

SECTION 4—RECORDS AND REPORTS.

ADDRESS BY THE CHAIRMAN, PROF. A. J. HENRY, WASHINGTON, D. C.

In the correspondence preliminary to the formation of a program several topics were suggested for discussion which, for one reason or another, had to be omitted from the final programme. With your permission I will reply briefly to some of them:

Binding of Forms No. 1009, Meteorological: I think Forms No. 1009 should be bound by all means. There will probably be a difference of opinion as to the best method of arranging them for permanent binding. The custom at the Central Office is to keep the forms together by months so long as they are frequently in use; for permanent binding, however, they are arranged chronologically by stations and bound by States. Generally three years' records are included in one volume.

Improvement of the original record (Form 1001) so as to adapt it for court use: Some official has suggested that the original record (Form 1001) could be improved with reference to its use in court. If the official had stated in what particular the original record is defective it would be much easier to discuss this question. The only defect I have found in it, so far as its use in court is concerned, is in the record of the time of beginning and ending of precipitation, on page 6. The record as now kept is not always understood by persons not connected with the service. It is therefore advisable to use the record of beginnings and endings found in the daily journal. In general, it is always preferable to furnish an account of the day's weather in the narrative rather than the statistical form. Too frequently the headings on meteorological forms fail to convey to the general public a true idea of the nature and character of the data given underneath.

A suggestion has also been made with reference to the improvement of the records in the interests of health seekers. I desire to call special attention to Form No. 1030, Monthly Meteorological Summary, as a means of conveying information regarding the local climate of a station. It contains, as you know, a record of the daily extremes of temperature, the daily rainfall, and the character of the weather, besides much statistical matter that is quite useful in studying local climate. It would be well to print an extra number of these forms and keep them on hand for supplying the information sought by health seekers and others.

We will now pass to the consideration of the papers on the program.

METEOROLOGICAL AND OTHER FORMS AND REPORTS: SHOULD THEY BE SIMPLIFIED; ARE MODIFICATIONS DESIRABLE?

By Mr. E. A. Evans, *Richmond, Va.*

In a letter of March 19 last from the Central Office, relating to the contemplated work of this convention, the chief of Bureau was pleased to indicate his desire that a full discussion be had at this

meeting of the methods now in vogue for conducting the business of the Bureau; at least so much of them as might properly come before this body. In pursuance of this it was later announced that the topic of "Meteorological and other forms and reports" would be discussed with respect to whether it was desirable and practicable to simplify or modify them.

The necessity for economy of time on stations is becoming a pressing matter with many of us, and more so now than ever, since the Bureau is growing and the demands upon us by the business and other interests of our respective communities are greatly increasing. Anything, therefore, that will tend to relieve the routine work of the stations so that time will be available in other directions would seem to be desirable.

The question, then, of the modification or simplifying of the forms in use, so far as it bears on this economizing of time, becomes a matter of some importance. I am free to say, however, that I do not see how any considerable saving of time is to be effected through modifications of our forms, unless a general revision and rearrangement of the system be had. As it now stands, it is the product of thirty years' practical working of the Bureau, and every form represents an existing necessity for it. From the standpoint of the man on station, however, there are some minor particulars in which it is thought changes for the better could be made. Let us consider for a moment Form 4013–Mis. (Monthly statement of maps issued). Does any essential need exist for the entry of the names and addresses, and dates on which taken up, of persons to whom maps are sent? Is it not practicable to omit these data? If it should be desired to know when a certain address was added or dropped from our list, could it not be more easily ascertained by referring to our complete station file of maps issued than through the medium of this form? Would not the essentials be supplied by giving in addition to the other data now provided for at the top of the form the total number of map addresses taken up or dropped each month? If this were done, the form could be reduced to the slip size, filing space saved—an important matter where thousands of them are filed, as at the Central Office—and the work of their preparation lessened in no slight degree.

The same is also true of Form 4028–Mis. (Changes in card forecasts). If it were allowable to omit entry of the names and addresses of persons or subcenters added or discontinued each month, the form could be reduced to the size of a brief fold and still make provision for all the important matter that caused it to be adopted in the first place, forming at the same time a ready means of ascertaining the amount of this class of work being done by each station. The name and address of each person receiving the forecast, both from the section center and all subcenters, together with date taken up and dropped, is doubtless kept on every station, and affords a convenient, accessible, and rapid means of getting at the particulars of any address, should such be needed for any purpose.

Again, in the case of Form 1022 (Hourly wind movement), why would it not be feasible to modify the instructions concerning it so that its tabulation could be done away with on long-record stations where a normal hourly wind movement has already been established? I do not know of any special use the data are being put to by the Bureau or the public, and it would seem as if for most scientific purposes the mass of this information already available would prove ample. Could not, therefore, a certain number of years' record be fixed upon as a

standard, and then have all stations falling below it continue to compile the form until they have completed the allotted number of years? Would any important interest suffer if this were done?

Also in the case of the Daily Journal (Form 1014), would it not be practicable to omit unimportant dates? There are usually, as we all know, a number of such days each month, days on which there is absolutely nothing transpiring not fully shown by other forms, yet under the present rules an entry must be made on such days. Does not this tend to an undesirable duplication of data, and could not the rules be so relaxed as to allow such dates to be treated as the judgment of the observer may direct? It is not thought that the value of the journal as a whole would suffer on this account, as everything thus omitted could be found in the other forms. Further, as duplication is a matter to be avoided, why not also omit the times of beginning and ending and amounts of precipitation except where it comes from sleet or hail, or is excessive, or is possessed of some special or unusual features of interest. Ordinary cases of precipitation are fully provided for in Form 1001, where they are vastly more compact and accessible than in the journal. Moreover, the journal is designed to keep a record of such weather characteristics as are "not easily susceptible of tabulation," and precipitation is not only so susceptible but is tabulated right along.

A simplification or condensing of forms might also be accomplished in our semiannual property report by combining with it Form 2028 (Certificate of property expended), and providing a better or more commodious arrangement for accounting for Bureau property at the voluntary observers' stations. In the case of Form 2034, Property Report, this can be done, if not contrary to regulations, by adding a line on the bottom margin, which is ample for the purpose, headed "Y property expended," and another for "Disposition." Now, as all "Y" property is already carried on the regular return, the special advantage this arrangement would offer would lie in the fact that the complete record of property transactions would then be contained on the one form, thus facilitating comparison and checking and avoiding the liability to error arising from transferring data from one form to another. In so far as the apparent need for an improved method of accounting for property at voluntary observers' stations is concerned, while I am of opinion that it is desirable, I am not prepared to suggest a way of doing it. I have been using a specially ruled blank for this work for several years past which, while it answers very well, might be changed for the better.

With regard to our card forecasts, I think a change could be made that would result in a considerable saving of time and labor. It is doubtless the experience of all section directors that once the cards are introduced in a neighborhood, additional requests for them are constantly coming in. On star-route lines in particular, these applications entail much time and trouble in finding out what mail facilities exist before definite action can be taken. This, it is thought, could be remedied by printing upon the back of the forecast card the legend "Applicants for this card will please state the time their mail rider leaves the railroad station with mail." With this information contained in the application we could tell immediately whether or not he could be served, instead of, as at present, having to write the applicant one or more letters on the subject, or to call on our postmaster, or to hunt the information up in our mail contract books.

In considering the question of forms, as outlined by the letter quoted

at the beginning of this paper, there remains but one thing more that it is desired to submit to this convention for discussion. It is as to the practicability of having all of the forms usually copied by letter press printed on thin paper similar to or the same as that used for the voluntary observer reports. The idea would be to put them up in the pad form and have the data entered thereon with indelible pencil, using carbon to obtain duplicates, the top copy to go to the central office and the duplicate to be filed at the station separately by means of some good filing device, forming books, as it were, that would hold a complete series of each individual form for a considerable number of years in a minimum of space and with a maximum of accessibility for reference, study, or other purpose. The effect of this would be to do away with the uncertainty and difficulty of obtaining good water copies, as is the case with forms made out with ink.

Now, Mr. Chairman, I believe it is generally conceded that the time of the man on station is valuable, and I am sure that if a feasible way can be found of lessening the work of preparing the forms in use he will heartily appreciate it, and that the time thus gained will be used to good advantage.

DISCUSSION.

Mr. E. C. Easton, of Baltimore, Md., spoke briefly of the advantage of using the card-catalogue system, which he stated was successfully used at Baltimore in connection with the reports of crop correspondents, voluntary observers, etc. He also described the method in use at Baltimore for filing blank forms, which consisted in taking the large envelopes used in mailing Form 1001 and placing each kind of form in a separate envelope, the grouped envelopes being stood on edge on shelves, whereby they are readily accessible. Mr. Easton submitted a schedule of work relating to meteorological forms for the information of the convention. The schedule follows:

DAILY.

Begin work daily at 12 noon, immediately after removing the wind sheet.

Count miles on wind sheet.

Enter miles on Form 1022. Verify totals for each six hours, for noon to noon, and for midnight to midnight.

Enter directions on Form 1021. Underscore 1 to 4 miles an hour. Where 0 miles are entered on Form 1022 enter 0 in corresponding space on Form 1021.

Verify entries of directions and velocities on Form 1001, 8 a. m. and 8 p. m.

Compute maximum velocities and directions and extreme velocity. Enter these figures on wind sheet in red ink and make permanent entries on Form 1001 in black ink. (It is customary here to make light pencil entries of maximum velocities until after the wind sheet is removed, when a more accurate measurement can be made.)

Compute precipitation. Enter beginnings and endings on wind sheet in red ink. Correct the register record to agree with the stick record. Enter amounts for each hour on wind sheet in red ink and make necessary entries on back of sheet. See that the twelve-hour amounts and other entries on wind sheet agree with the 8 a. m. and 8 p. m. entries on Form 1001. Make all totals and time entries on wind sheet agree with similar entries on page 6, Form 1001.

Compute sunshine. Enter "clear" and "cloudy" on wind sheet.

Compare entries on Form 1083 with entries on Form 1001. Verify the reductions of barometric pressure, dew point, relative humidity, and vapor pressure. Apply red ink correction figures to the trace sheet on the barograph for the two preceding observations.

Consider temperature entries for the preceding a. m. and p. m. observations, making a trip to the thermograph for the purpose. See that the maximum temperature is as high as, or higher than, the exposed temperature of the current and

preceding observations. If, in the morning, the maximum temperature is recorded as being higher than the exposed temperature of the preceding observation, see that the thermograph trace confirms the entry. See that the minimum temperature is as low as, or lower than, the exposed temperature at the current and preceding observations. If, in the evening, the minimum temperature is recorded as being lower than the exposed temperature of the preceding observation, see that the thermograph trace confirms the entry. Make required red-ink entries on thermograph trace of differences for 8 a. m., 8 p. m., maximum, minimum, and special, temperature observations. Examine carefully the preceding twenty-four hour midnight to midnight period on the trace sheet for its highest and lowest temperature record, and enter the results (corrected) in proper columns on page 6, Form 1001.

See that cloud entries are correct, and that the total amounts and kind are consistent with the entry of "state of weather."

Special.—Enter dial reading on wind sheets on each Monday, and on first of each month.

Enter required reference to precipitation on the back of the last wind sheet for the month.

In correcting any part of the meteorological record at any time, always reflect whether the correction made involves other entries on the forms, and if so, carefully apply the resultant corrections in all places required. This is important, and should be done at once.

AT THE END OF THE MONTH—FORM 1001.

Obtain algebraic sums of "observed reading" and "total correction;" this should agree with sums of "station" in barometic columns. In like manner the algebraic sums of footings for "station" and "correction for elevation" should agree with sums of "reduced."

When computing mean current wind direction at 8 a. m. and 8 p. m., preserve record of work; the sums for each direction may then be used for entries of "number of times and percentage" in the summary, thus avoiding a repetition of work.

Always refer to special observations for pressure extremes, as indicated in note in Form 1001.

Page 6. See that the sum of "range" is the difference between the sum of "maximum" and the sum of "minimum."

See that "dep. since first of month" as given on last day is the difference between the sum of "mean" and the sum of "normal," and that it bears proper sign.

See that "dep. since Jan. 1," as given on last day is algebraic sum of "dep. since first of month" on last day of current month and "dep. since January 1" on last day of preceding month, and that it bears proper sign.

See that total precipitation is the sum of precipitation entries on pages 2 and 3.

Verify precipitation departures since first of month and since January 1, in manner indicated for temperature departures.

Review carefully all entries of beginnings and endings of precipitation. If rain was falling at a p. m. observation, see that dashes pass through the 8 p. m., "ending" space for that day, and the 8 a. m. "beginning" space for the following day, on page 6. If rain was falling at an 8 a. m. observation, see that dashes pass through the 8 a. m. "ending" space and the 8 p. m. "beginning" space for that day, on page 6.

THE EXAMINATION OF MONTHLY METEOROLOGICAL REPORTS OF VOLUNTARY OBSERVERS: IS IT DESIRABLE TO REPORT BACK TO THE VOLUNTARY OBSERVER THE ERRORS AND IRREGULARITIES DISCOVERED IN HIS REPORT?

By Mr. J. W. BAUER, *Columbia, S. C.*

It may appear at first glance that this question admits of a simple affirmative or negative answer. Nevertheless, there are underlying principles involved that merit careful consideration, and, although these principles are not confined strictly to this topic or to the work of the Weather Bureau, they fully cover it.

To take the negative side of this question might seem to be a purely selfish view of it, from the section director's standpoint only, and would be to give the increased work involved and the danger of unwittingly giving offense to a voluntary observer a greater prominence than to the principles that should govern us in our work.

The Weather Bureau is a part of the National Government, and as such the Bureau is strictly accountable to the public for the manner of performing the work in which it is engaged. Nevertheless, its work is not, strictly speaking, a governmental function. The work it does may gain a temporary weight or prestige because done under the fostering care of the Government; but eventually it is judged solely on its intrinsic merits. It might as properly be undertaken by private individuals or corporations, and no doubt would be were it not that the expense involved in collecting the necessary data and the difficulty of profitably marketing weather data, forecasts, etc., make it prohibitive.

The benefits to be derived from the forecasts and the other information furnished to the public are so many and so diversified, and are so intimately connected with the daily affairs of the whole people, as to make the work of the Weather Bureau a proper form of governmental paternalism.

In the light of the above, the topic may be discussed under three subdivisions, as follows: First, the relations to and duties owed the public by the employees of the Bureau; second, the relation of voluntary observers to the public; third, the relation of the Bureau to the voluntary observers.

For the purposes of this paper it will be sufficient to say, in discussing the first subdivision, that as paid servants of the people, selected to do a designated work and retained on account of their demonstrated skill and experience, the employees of the Bureau owe it to the public to render only such reports and publish only such data as have at least their own honest certificate of correctness, and which are as nearly accurate as their instruments, their knowledge, their skill, and their experience can make them. Anything short of this, "they eat the bread of their masters for naught."

The Weather Bureau compilations of meteorological records and data are accepted as conclusive evidence by the courts of law. This includes not only the observations taken at regular Weather Bureau stations, but also the records of voluntary observers, for the accuracy of which the Weather Bureau stands sponsor, and vouches for them under the seal of the Department of Agriculture. As individuals the employees often certify under oath to voluntary observers' records when such records are taken into court. These reports are at times taken upon the witness stand, either by securing copies from the voluntary observers or from the section center or from both places, and in the latter event it would discredit their accuracy if the two differed in any material respect.

No one has a just and meritorious claim on public gratitude for doing anything he is paid to do, except for the manner in which he does it; but when a man, or any number of men, take up a certain line of work that benefits their fellow-men more than themselves, they are deserving of the highest praise. In this class are the voluntary observers of the Weather Bureau. The record of observations taken at any one station covers but a limited area, and by itself would be of little account in determining the climatology of a region; yet when combined with the records of thousands of other stations, each one becomes

an important factor in the whole vast scheme of climatology. The aggregation of voluntary observers' reports is possible only through the agency of the section centers of the Weather Bureau (or a like organization), and it is only when so collected or assembled that the highest value of even a single station's reports is developed. It is through this assembling that the public are enabled to have a share in the benefits derived or to be secured from voluntary observers' reports. However, when these reports reach the public, the latter have a right to demand as great an accuracy and reliability for them as though the reports originated in regular Weather Bureau stations. How can this result best be attained?

It is perhaps a universal experience—a truth that has been formulated in an axiom—that all men are liable to make mistakes. Who of us at sometime or other have not made mistakes and errors in his routine work as an observer, however conscientious in his efforts to avoid them? I venture to say not one. Is it reasonable then to expect absolute accuracy in the work of voluntary observers, when we, ourselves, can not avoid errors?

Admitting the desirability, as well as duty, of presenting the work of the Bureau to the public free of error, and admitting that errors are liable to occur, and frequently do occur, we come to the gist of the topic, which is, How can irregularities and errors best be corrected when discovered?

This brings into the discussion the mutual relations between the section directors representing the Weather Bureau and the voluntary observers. This relation may be, and often is, of a dual nature, namely, official and personal, perhaps better expressed as friendly or social. The two are not inconsistent. The first, although always pleasant, is usually formal, the latter sometimes very cordial. The section director regards the voluntary observer as an indispensable aid in his work, to whom all encouragement should be given and every courtesy extended, and who is worthy and deserving of all that can be done for him, either officially or in any other manner in which the director can show his appreciation. The voluntary observers are as a class, men who take up the work in a spirit of scientific investigation after truth, and in that spirit are as desirous as the Bureau possibly can be to have their observations and reports as nearly absolutely correct as painstaking care and thorough examination can make them. The first comes within the province of the observer himself; the latter is the duty of the section director. The voluntary observer is the best, in fact the only one competent, to decide what he intended to put on record in his Form 1009—Meteorological. The section director is oftimes the more competent to say how the matter should be recorded. Therefore, when an error or an irregularity is apparently discovered in any Form 1009—Meteorological, it would be presumptuous and show a lack of courtesy to correct the same without first communicating with the person who rendered the report. No voluntary observer should take offense upon receiving such a communication relating to the accuracy of his report, but, on the contrary, he should appreciate it as a kindness. In this, as in many other things, it is not so much the thing done as the manner of doing it that gives just cause for resentment. An error or an irregularity in a voluntary observer's report is neither a crime nor a misdemeanor, nor should the section director assume the rôle of censor, but when reporting back the discovery of an apparent error he should frankly and courteously inform

the voluntary observer of the discovery, and ask that the matter be given careful attention, with a view of arriving at the truth.

The CHAIRMAN. The questions discussed by Mr. Bauer are vital ones. They must be met sooner or later by the section director. I commend them to your careful consideration.

THE BEST MEANS OF PRESERVING RECORDS FOR REFERENCE AND STUDY.

By Mr. S. C. EMERY, *Memphis, Tenn.*

The preservation of meteorological records and their arrangement in convenient form for reference and study are subjects of great and growing importance, and one well worthy of careful consideration.

The purpose of this paper is to offer a few suggestions regarding the compilation and arrangement of those data most often brought into use in connection with the ordinary business and professional affairs with which we are in daily contact, that in the end systematic and uniform methods may be adopted. Compared with present methods in this line, those in vogue during the early years of this service appear extremely crude, and yet they were the best that the limited experience of the time could suggest. Later, as new features were added and the accumulation of data assumed greater proportions, old methods gave place to new, so that during the first eighteen or twenty years of the service changes in the manner of keeping the records were frequent, and not until about 1890 do we find the station record of observations in the convenient and satisfactory form now used.

The present record (Form No. 1001) is well suited for the purpose intended, and I can not see wherein it could be improved, being in compact and handy form for easy reference.

The recorded data for a single day is a relatively small matter, but, like bricks under the hand of the skilled artisan, the slowly added items soon form a monument in which the individual elements become obscured, and unless specially marked, many valuable ones are, for the time being at least, lost to sight. Therefore the necessity of setting apart the most commonly referred to elements in a convenient and comprehensive manner becomes at once apparent.

The successful merchant is the one who always aims to have on hand what the people want and when it is wanted. This can apply as well to the successful Weather Bureau official, who can have always at his fingers ends, if he will, anything in the way of weather lore likely to be required by the public he tries to serve. This may entail some extra labor and considerable patience, but in the end it will result in a great saving of time and vexation, and prove a source of satisfaction to the official as well as the inquirer.

The Weather Bureau station is a repository of interesting and valuable statistics in various forms, but unless these statistics and records are in convenient reach and so arranged that they can be found when wanted, they are of little use. Weather Bureau officials throughout the country are called upon daily, and often many times each day, for all sorts of information regarding past meteorological events and climatic data generally. This is especially true of newspaper men, who very frequently desire material for a weather story. In such cases, and in fact in most cases, comparative data are found

most useful, for it is only through comparison that climatic statistics become intelligible.

I would first suggest the keeping of a sort of handbook, or station reference book, in which could be entered a roster of the station force and other employees, with a record of the various changes as they occur; all special instructions governing the conduct of the station, as well as those issued by the official in charge to the station force; addresses of all persons and places to which the various reports are sent, either by telegraph or mail; map and card lists, etc.; in fact, such a complete memorandum of the routine work that anyone suddenly assuming charge would have every detail before him. Then the daily maximum, minimum, and mean temperature, a separate page for each, and the daily precipitation, all arranged by months, and one page being capable of containing the data for a long period of years. By having the absolute maximum and the absolute minimum temperatures in red, or say all maximums above 90° and all minimums below zero, the particular temperatures most desired could be easily singled out. I have such a record and find it very useful. When once worked up from the numerous forms in which these data are usually found, its continuance from month to month is very simple and will well repay one for the trouble. When a sufficient number of stations have completed a period of thirty years or more, the data so prepared could be turned over to the Central Office for publication in book form.

In addition, the reference book should contain the monthly mean and normal monthly temperatures, daily normal temperature and rainfall, highest and lowest monthly temperature, and, if a river station, the highest and the lowest river stages during the month.

Another thing that would be found useful is an index to certain tables and reports in the Monthly Weather Review and other Bureau publications, so they can be readily referred to when necessary. This indexing can be done from time to time by simply making a note of reference to any article or table that the official might encounter that would seem likely to come into frequent use. I would also suggest the keeping of a brief record of all extraordinary occurrences, such as excessive rains, snows, protracted droughts, unusually hot or cold spells, severe storms, and floods, etc. Only a brief entry need be made, with a reference to the details elsewhere recorded. If given under proper heads and systematically arranged, such a record would be a great convenience and result in the saving of much time. It would also present a more or less complete history of the station, while a search through the old records, journals, etc., in the preparation of such history will familiarize one with past events as nothing else can.

The work herein mentioned could be accomplished by slow degrees, as time permitted, so that it would not be a great burden or interfere with other duties. It is probable that most stations have an arrangement of data similar or even better than that herein mentioned, but the object I have here in view is to secure complete uniformity in this regard and call attention to the need of a reference book suitable for recording those matters herein set forth, so that the same system may be in use at all stations.

Mr. J. D. Blagden, of the Memphis station, has proposed a very neat form of record, which shows at a glance the daily maximum, minimum, mean, and normal temperatures and rainfall in a way that is much more comprehensive than when given in figures, and also shows in a graphic manner the daily march of temperature through

the seasons. Maximum wind velocities and snowfalls could also be treated in the same way, gales having their direction indicated. The record consists of vertical columns drawn to a scale on horizontally-lined paper, the distance between the lines representing a unit of the scale. For temperature the spaces represent degrees, and for precipitation and barometric pressure they represent one hundredth of an inch. By shading portions of the column and leaving other portions unshaded different data can be represented. This form of chart is frequently used in statistical work, and, being easy to prepare, I am of the opinion it can be used to advantage in meteorological work. However, instead of having each sheet contain the record for four months, Mr. Blagden proposes to have them one-half the size and contain the record for two months.

I would further suggest that a copy of the barograph and thermograph trace be kept at the station and attached to the corresponding data in the press-copy book of Form No. 1026 (where made), and that a press copy of the wind sheets be furnished all stations.

In conclusion, I wish to refer to a paper presented at the Omaha convention by Mr. Walz in regard to studies of climate, and to state that if some such plan as he therein outlines could be carried out at all stations, and every Weather Bureau station supplied with a copy, it would be a great convenience and fill a long-felt want. I would like to see such a plan carried out, and think with a little effort it could be, though possibly in a form somewhat abridged from that referred to.

The CHAIRMAN. The chair would state, in reference to the last part of Mr. Emery's paper, that an attempt was made several years ago to press copy wind sheets for all stations in order that a copy might be sent back to the stations. The labor of press copying was so great, however, that the attempt had to be abandoned. Press copies of the wind sheets for a few of the larger stations are now made, but it does not seem possible at present to undertake to furnish all stations with press copies.

With reference to the barograph and thermograph sheets, I would suggest that in all cases copies be made for file at the stations before forwarding the sheets to the central office.

THE NECESSITY FOR BINDING AND OTHERWISE PRESERVING THE PUBLICATIONS OF CLIMATE AND CROP SECTIONS.

By Mr. W. S. BELDEN, *Vicksburg, Miss.*

[Read by title.]

After the expenditure of much time, energy, and money in obtaining, tabulating, and printing reliable meteorological data the importance of properly preserving such publications becomes a question worthy of careful attention.

The two most important section publications are the weekly crop bulletins and the monthly section reports. Each publication has its special value, but to a very large extent the information contained in the former is to be found in the latter. Hence the necessity for carefully preserving the section reports at once becomes manifest. It is believed that at least two series of the weekly crop bulletins should be preserved and at the close of a season be bound with heavy manila wrapping paper by use of paper fasteners, labeled, and filed in a convenient place for reference.

The increasing number of voluntary observation stations and the gradual improvement in the character of the data which is compiled in the monthly section reports is commensurately increasing their value. Nearly all voluntary stations are now equipped with standard instruments and instrument shelters. Increased accuracy and uniformity in the time and manner of recording observations has resulted from the "Set Max." innovation, and improvement in the exposure of instruments is sure to follow the inspection of substations, for which provision has recently been made.

The monthly section summaries contain the detailed reports of the two most important meteorological elements, precipitation and temperature, observed at both the regular stations of the Bureau and all classes of substations using thermometers and rain gauges. In the preparation of these reports a great amount of energy and time is expended in order to accurately tabulate the results of all observations.

Within the past few years uniformity in size and in the general character and make up of the monthly section reports has been secured and a very handy file case provided in which to place a limited number of the loose reports as they are received from day to day. As these publications are beginning to accumulate and as their value is increasing from year to year, a uniform plan of preserving a portion of them by substantial binding should be given due consideration, along with other improvements to be made in the usefulness of the Bureau.

In order to lessen the cost of binding, and at the same time secure a volume not too large for convenient use, it is believed that the monthly reports of a section for a period of five years should be bound in one volume. Such a volume would be a trifle smaller than that of the monthly weather reviews for the year 1900, excepting in the case of Iowa and California, whose reports, being more extensive than those of other sections, should be bound perhaps biennially or triennially. As each section director finds greatest use for his own reports, and next to these the reports of neighboring sections and practically no use for the reports of many remote sections, the following plan of preserving the monthly section reports is suggested: The file case now in use being large enough to contain these reports for half a decade, let each section director at the end of five-year periods name about 10 sections whose reports are most frequently used and have these substantially bound, while those of the remaining sections may be preserved in fairly convenient form by binding with heavy wrapping paper, as was suggested for the weekly bulletins.

This plan would necessitate a cloth or board binding for about 500 volumes every five years, which can be well done by contract for $1 per volume and probably for a less sum.

While it would, perhaps, be desirable to have each section center supplied with the substantially bound monthly reports of all other sections, it is doubtful if this extension could be considered entirely practicable at this time.

THE USE OF COLLECTED DATA.

By Mr. W. S. PALMER, *Cheyenne, Wyo.*

[Read by title.]

Although I selected as a topic for this paper "The use of collected data," possibly I should have better indicated its contents had I headed it "The misuse of collected data," for that more clearly defines the

topic I wish to discuss. I should never wish to discourage the true seeker after truth, the scientist, from the investigation of subjects and the reaching of definite conclusions from accurate and reliable data; but we are all aware that too many false conclusions are reached by investigators, not because the data used by them is not reliable and accurate, but because they have not fully considered all of the circumstances and conditions under which such data has been collected. In a recent number of the Monthly Weather Review the editor has very tersely stated this truth, as follows: "One may have the best of observational data and yet go far astray when he attempts to reason from it." If we are to reach true conclusions, we must be sure that data has been properly considered and that conclusions are logically correct, as our results must satisfy the criticism of the logician as well as the layman.

A great number of specific cases might be cited to illustrate this generalization already stated, but a few will suffice.

The possibility of an unwarranted conclusion is instanced in a recent issue of an agricultural journal. The writer states in broad and general terms that "southern Indiana, which has been cleared too much, years ago, when there was still much timber standing, produced far better crops than now," and that the destruction of the forests reduced the yield of crops. There is no reason to doubt the writer's ability to accumulate data showing that the forests of that section have been destroyed, and that there has been a reduced yield of crops, but the conclusion that forest destruction reduces yield of crops does not necessarily follow. If the essential elements of fertility are constantly taken from the soil, and none supplied, the soil will soon become exhausted, a fact strikingly illustrated by the many abandoned farms of the extreme eastern States. Could not the writer have ascribed the reduced yield of crops to the depletion of the soils, as well as to the destruction of the forests?

Much study has been given of late years to the subject of weather and crime. Most of the investigators, I believe, have confined themselves to data collected in the large cities of the country. If the records of the police department of a metropolitan city show that less of a certain kind of crime is recorded on exceptionally warm days than on other days, are we not as much at liberty to conclude that the police are less active on hot days than they are on days of a mild and pleasant temperature, as that less crime is committed? All factors which go to make up the data used should be considered and given due weight, if conclusions are to be accredited.

Some time ago a table of the frequency of hail in the United States was published in the Monthly Weather Review. The table referred to seems to show that the hail frequency in Colorado is six times as great as that of Wyoming, its near northern neighbor. During the period studied by the authors of the article there were about six times as many reporters in Colorado as in Wyoming, and six times as many hailstorms were reported for Colorado as for Wyoming. I believe that the fact of the number of reporters for the different States was not fully considered by the authors of the article, and the conclusions arrived at are not, at least to my mind, satisfactory.

I do not care to add other cases of a similar nature. As true investigators we should be careful, before arriving at our conclusions, that they follow logically from the data used.

RECORDS IN COURT.

By Mr. C. E. LINNEY, *Chicago, Ill.*

[Read by title.]

A record is defined as "a written memorial made by a public officer authorized by law to perform that function, and intended to serve as evidence of something written, said, or done." (See Railroad Company *v.* Morgan, 69 Ill., 492; also 115 Mass., 168.) What is evidence as here used? In its legal acceptation it includes all the means by which any alleged matter of fact, the truth of which is submitted to investigation, is established or disproved. (1 Greenleaf Ev., sec. 1.) If, therefore, a part of the means which it is desired to use to establish the truth of an alleged matter of fact be the official books, records, papers, or documents of an office of the executive department of the Government, the Congress has said that either the original or an authenticated copy is admissible to prove the facts therein contained. (Rev. Stat. U. S. (1878), sec. 882.) The wording of the statute is, "copies of any books, records, papers, or documents in any of the Executive Departments, authenticated under the seals of such Departments, respectively, shall be admitted in evidence equally with the original thereof."

It is not necessary that the book, record, paper, or document submitted should bear directly upon the point at issue; it is admissible if it tends to prove the issue, or constitute a link in the chain of proof, although, alone, it might not justify a verdict in accordance with it. (1 Greenleaf Ev., sec. 51; 134 Mass., 217; 54 Ill., 266; 5 Iowa, 535.)

Writings are of two classes, public—the acts of public functionaries in the executive, legislative, or judicial departments of the Government—and private, or those of the individual, which, in general, must be proved to be genuine. Public records, or writings, include those which the various officials of the Government are required to enter in books or registers in the course of their public duties, and which occur within the circle of their personal knowledge. Public writings are, further, judicial and not judicial, of record and not of record. There are also records which partake of both a public and a private character, for the former are wholly subject to public inspection, while the latter are not at all, thus a middle class arises which is called quasi public. These are not subject to the inspection of the public if the same is, in fact, against public interest. It is probable that the records, documents, papers, and books of the Weather Bureau may be placed within the latter class and, if in the judgment of the court, or of the chief executive officer, or the head of the Department in whose custody or under whose control these may be kept, the inspection would be injurious to public interests, an inspection will not be granted. (1 Greenleaf Ev., sec. 626; 109 Mass., 487.)

The general rule is that writings introduced in evidence must conform to the usual and ordinary tests of truth, the oath and cross-examination; but official registers or books kept by persons in public office in which they are required, either by statute or by the nature of their office, to write down particular transactions occurring in the course of their public duties and under their personal observation, and all other documents of a public nature are generally admissible in evidence, notwithstanding their authenticity is not confirmed by these usual tests of truth. An extraordinary degree of confidence is reposed in such documents and records because they have been made

by an authorized and accredited agent appointed for the purpose, and also because of the publicity of the subject-matter. And since these records are made for the benefit of the public those who are given the authority to make the memorials really act as the agents of all the individuals who compose the State, and every member of the community may be supposed to be privy to the investigation. It follows, therefore, from the credit due to the acts of an agent, and from the public nature of the facts themselves, that such documents are entitled to an extraordinary degree of confidence, and it is not necessary that they be confirmed and sanctioned by the ordinary tests of truth. (1 Greenleaf Ev., sec. 483; 17 Ill. Ap., 136.)

These books, records, papers, and documents are recognized by law because they are required to be kept by law, because the entries in them are of public interest and notoriety, and because they are made under the sanction of an oath of office, or at least under that of official duty. (1 Greenleaf Ev., sec. 484.) It is deemed essential to the official character of these books and records that the entries in them be made promptly, or at least without such long delay as may impair their credibility, and that they be made by the person whose duty it was to make them, and in the manner required by law, if any has been prescribed. They belong to a particular custody, from which they are not usually taken but by special authority, granted only in cases where inspection of the book or record itself is necessary, for the purpose of identifying the book or record, or the handwriting, or, more particularly, of determining some question arising upon the original entry. When the books themselves are produced they are received in evidence without further attestation, but they must be accompanied by proof that they come from the proper custody, being presented by the official in charge of the station or some of his duly appointed assistants. (12 Price, 625; also 4 .Price, 216.) Books of this public nature being themselves evidence, when produced, their contents may be proved by the introduction of an immediate copy duly verified. (1 Greenleaf Ev., sec. 484; 105 Ill., 419, and 27 Ill., 303.)

To entitle a book, record, or paper to be considered of an official character, or as an official register, it is not necessary that it be required to be kept by an express statute, nor that the nature of the office should render the book indispensable, it is sufficient that it is directed to be kept by the proper authority and that it is kept in accordance with that authority. (1 Greenleaf Ev., sec. 496; U. S. Stat. L. (L. & B's. Ed.) 133, sec. 1790.)

Where proof of a record is by copy, an examined copy, duly made and sworn to by any competent witness, is always admissible; but whether a copy certified by the official having the legal custody of the books, records, or papers, he not being specially appointed by law to furnish copies, is admissible, has been doubted, but Greenleaf says that the weight of authority is in favor of such copy being evidence, where the copy is given by a public official whose duty it is to keep the original. (See 1st Greenleaf Ev., sec. 485, citing 13 Fla., 602; 120 N. Y., 114, and 62 Me., 416; adverse 20 Ill., 144, and 105 Ill., 419.) This matter, however, has been anticipated, and in Instructions to Observers (1895), on page 23, we find this given:

Officials of the Bureau must bear in mind that the records which they keep are a part of the records of the Department of Agriculture, and that by law they are in the custody of the Secretary of Agriculture. Officials in charge of stations will inform applicants that duly certified copies are always furnished when necessary for legal purposes.

And, as previously stated, these authenticated copies are made evidence by the United States Statutes. (Sec. 882, Rev. Stat. U. S.)

It is to be borne in mind, however, that these books, records, papers, and documents are in general not evidence of any facts which are not required to be recorded in them, and which did not occur in the presence of the registering officer. (1 Gilman, 347; 5 Mo., 403; 1st Greenleaf Ev., 493.) The general rule of law is that a certificate of a mere matter of fact not coupled with any matter of law is never allowed to be admitted as evidence. For, if the person making the record was bound to record the fact, then the proper evidence is a copy of the record, duly authenticated. As to matter, however, which he was not bound to record, his certificate, being without his official capacity extra-official, is merely the statement of a private person, and will be rejected. (17 Ill., 54; 6 Cowen, 261; 3 Peters, 12–29; 15 Mass., 336; 1st Greenleaf Ev., sec. 498.) Copies of records under the seal of the Secretary of Agriculture are deemed of a higher character and credit than sworn copies, because it is presumed that they have passed under a more critical examination. (1st Greenleaf Ev., sec. 503.)

The text in the decision of the City of Evanston *v.* Gunn (99 U. S., 660), which clearly sustains the records of the United States Weather Bureau, is as follows: Mr. Justice Strong delivered the opinion of the court:

The admission in evidence of a record kept by a person employed by the United States Signal Service (United States Weather Bureau, authorized successor) at Chicago was objected to at the trial, not because it had not been properly made, identified, and proved, but for the alleged reason that "there was no law authorizing such records to be used, and because it was not competent testimony." * * *

We have, then, only to consider the objections that were made, the only ones that appear in the bill of exceptions, and they present the question whether the record, conceding it to be properly proved, was competent evidence. It may be admitted there is no statute expressly authorizing the admission of such a record as proof of the facts stated in it, but many records are properly admitted without the aid of any statute. The inquiry to be made is, What is the character of the instrument? The record admitted in this case was not a private entry or memorandum. It had been kept by a person whose public duty it was to record truly the facts stated in it. Sections 221 and 222 of the Revised Statutes require meteorological observations to be taken at the military stations in the interior of the continent and at other points in the States and Territories, for giving notice of the approach and force of storms. The Secretary of War is also required to provide, in the system of observations and reports, in charge of the Chief Signal Officer of the Army, for such stations, reports, and signals as may be found necessary for the benefit of agricultural and commercial interests. Under these acts a system has been established and records are kept at the stations designated, of which Chicago is one. Extreme accuracy in all such observations and in recording them is demanded by the rules of the Signal Service, and it is indispensable in order that they may answer the purposes for which they are required. They are, as we have seen, of a public character, kept for public purposes, and so immediately before the eyes of the community that inaccuracies, if they should exist, could hardly escape exposure. They come, therefore, within the rule which admits in evidence "Official registers or records, kept by persons in public office, in which they are required, either by statute or by the nature of the office, to write down particular transactions occurring in the course of their public duties or under their personal observation." (Taylor Ev., sec. 1429; 1st Greenleaf Ev., sec. 483.) To entitle them to admission it is not necessary that a statute requires them to be kept. It is sufficient that they are kept in the discharge of a public duty. (1st Greenleaf Ev., sec. 496.) Nor need they be kept by a public officer himself, if the entries are made under his direction by a person authorized by him. (Galt *v.* Galloway, 4 Peters, 332.) It is hardly necessary to refer to judicial decisions illustrating the rule—they are numerous. A few might be mentioned, citing De-Armond *v.* Neasmith, 32 Mich., 231; Gurney *v.* Howe, 9 Gray, 404; Cliquots' Champagne, 3 Wall., 114; 70 U. S., 116. We think, therefore, that there was no error in admitting the records kept by the person employed for the purpose by the United States Signal Service.

RECORDS IN COURT.

By Mr. P. F. Lyons, *St. Paul, Minn.*

[Read by title.]

The meteorological records for St. Paul are frequently adduced, both in the State and the United States district courts, for the purpose, in most cases, of aiding to prove or disprove the claims of litigants in actions for damages to persons or property, and in which the weather may be a factor. In every case of importance, and on which wind, rain, snow, ice, fog, flood, and temperature may have a bearing, the records are either examined or brought into court as testimony by one or both litigants. Appearance in court, though often an inconvenience, ought not to be a hardship to an observer, since the court and attorneys are usually very obliging, and, when possible, will inform him by telephone or messenger just when they are ready to take his testimony. At times a certificate from the observer will be accepted in lieu of his presence. It is only when he is compelled to journey to outer places that there is much inconvenience; but even then there is no one of us, I presume, who is not ready and willing to undergo some inconvenience and even sacrifice in the furtherance of law and justice. But in doing so it is well to be prudent and cautious, and to be careful and not be led into the intricacies and mazes that may be laid by the skilled attorney and cross-questioner. It is unquestionable that the vast majority of attorneys are of high ideals, honorable, and upright; nevertheless, most of them consider, and no doubt rightly so, that it is not only their privilege but sacred right to astound or confuse a witness on the stand. A witness whose veracity may be doubted, or who may be suspected of bias, deserves to be so treated; but such treatment can not be said to apply to educated and disinterested public officials who base their evidence on official records, and severe cross-examinations, etc., can serve but little purpose aside from giving the attorney an opportunity to display his talent in that line. But if the witness confines himself to his records, and does not attempt to answer any of the theoretical or abstruse questions that may be put to him, he remains on impregnable ground.

In relation to the above, I will give two instances from my experience, in the first of which I appeared in answer to a subpœna last winter, in the district court of Ramsey County, State of Minnesota, in a case in which the city of St. Paul was defendant in a suit for personal injury alleged to be due to the city's negligence, and in which snow and ice figured.

When put on the stand, one of the attorneys for plaintiff commenced what I considered an effort to "work the jury" with a "Oh, ha; so you are Lyons, he—the man that guesses so much at the weather; prophet, eh?" The point that the city aimed to establish by my testimony was that the temperature rose above 32°, or freezing point, on the day of the alleged injury, and which it did establish. This was adverse to the other side, and so their attorney took me in hand, and, after parleying a little, suddenly put the question, "At what hour of the day does the temperature go above freezing, and when does ice or snow melt?" To which I answered: "The hour or time at which the temperature rises above 32°, or freezing point." He was evidently put out a little by this answer, and took another tack and parleyed some more, after which he suddenly renewed the question and quickly received the same answer as before. He then turned

to the jury, and either in a real or feigned fit of irritation, exclaimed: "That's just like your people's method of prevarication." To which I replied, promptly and emphatically, "No other man can give you a more definite answer." That ended my testimony, and no further questions were asked, and I stepped down from the stand.

Shortly afterwards I was subpœned and appeared in the same court, and again in an action for personal injury in which the City Railroad Company was defendant. Their aim was to show that the snow on the ground was partly responsible for the alleged injury to plaintiff, who attributed it to the negligence of the railroad company. After testifying for the defendent, the attorney for the plaintiff started off with "Oh, so you are Lyons that we read so much about. Ah, well, Lyons, you consider yourself pretty reliable, don't you, and you are never off about the weather?" To which I replied: "That is for the public to decide. I don't consider it proper for one in the public service to indulge in self-praise," and that ended the matter, and I stepped down from the stand, as before.

The attorney in the first case mentioned, in my opinion, aimed to have me stultify myself by fixing an hour at which the temperature, when below 32°, rises above it, and in case of my attempting to do so he would not need to be a great attorney to compel me to show by my records that there was no fixed time for the temperature to rise above 32°, and that it might do so at any hour of the day or night. The attorney in the second case, no doubt, desired me to extol myself by telling the court and jury how reliable I was, etc., and after that he would, no doubt, bring up some story about some forecast or other saying about the weather, and try to weaken my evidence or show that it wasn't worth much.

If the foregoing will be of any service to the officials of the Bureau in connection with the use of meteorological records in court, it will suffice for the little time spent in its preparation.

SECTION 5—CLIMATE AND CROP SERVICE.

ADDRESS BY THE CHAIRMAN, MR. JAMES BERRY, WASHINGTON, D. C.

From a meager beginning in 1887, when the National Climate and Crop Bulletin did not exceed in size any one of the 44 State Section bulletins now issued, the climate and crop service of the Weather Bureau has grown until to-day its several features constitute a work which, in the opinion of the speaker, is exceeded in importance and value by but one other branch of the Bureau's work, namely, the daily forecast and storm warning service, which, I think we all must admit, is the Bureau's first and most important duty.

With 42 well-organized State climatological services, besides those of Cuba and Porto Rico, we have a most efficient means for the collection and dissemination of information. We are amassing meteorological records from more than 3,000 stations, which, as well as providing for immediate use data required for current climate and crop publications, will prove of inestimable value to the future scientific investigator.

Until recent years the filling of requests from the various sources for special data constituted no small item of work at the central office in Washington. Now practically all such requests are satisfactorily met by the monthly reports of climate and crop sections. Scarcely a

question can be asked concerning the climatic features of any part of the country, however exact as to time and place, that is not readily answered by these publications.

The national and the section climate and crop bulletins form a most complete history of the weather conditions throughout the period of planting, cultivating, and harvesting of crops. Much more might be said with regard to the system by which our crop work is conducted, but you are all familiar with it, and I will not consume time in dwelling thereupon.

In our climate and crop work we would be powerless to accomplish much that is valuable without the cooperation of our voluntary observers, displaymen, and crop correspondents, who give, without compensation, a part of their time each day, either in taking observations, distributing forecasts, or reporting the climate and crop conditions. Too much praise can not be accorded these public-spirited citizens for the sacrifices made to aid in this important work.

The foreign visitors, often the representatives of their respective governments, calling at the Weather Bureau, invariably evince a lively interest in the crop reporting system of the Bureau. They are favorably impressed with its thoroughness of conception and execution, and invariably express astonishment at the rapidity with which the work is accomplished, as well as admiration for its completeness.

The establishment of voluntary meteorological stations and the issue of climate and crop publications is not the only work conducted by the State climatological sections. It is through them that arrangements are made for the dissemination of the weather forecasts and special warnings. Nearly 2,000 forecast telegrams are sent out at Government expense daily to carefully selected points throughout the country, and these dispatches are multiplied by the various means of dissemination until a grand total of nearly 150,000 weather bulletins are displayed daily in time to give the public information as to the expected weather conditions of the succeeding day. In the dissemination of weather information the cooperation of the Post-Office Department, which is cheerfully given, is indispensable. From the Postmaster-General down to the rural free-delivery carrier our efforts in this direction are heartily seconded. Before the convention closes we will have with us Hon. A. W. Machen, the general superintendent of the free-delivery system of the Post-Office Department, who has taken a keen interest in forecast distribution through the rural free-delivery mail service of the Post-Office Department, and we have the best reasons for believing that his subordinates will assist, so far as they may without detriment to the postal service, in further extending this work. Two subjects in our official program relate directly to the work in which Mr. Machen is deeply interested, viz, "Is it advisable to distribute the night forecasts by the rural free delivery?" and "Weather symbols on rural free-delivery wagons," and before the close of the convention we will have the pleasure of hearing something of especial interest on these subjects directly from Mr. Machen.

With the rapid growth of the rural free-delivery service, and consequent increase in forecast distribution, the need for a forecast printing machine becomes more urgent. Professor Marvin has, I believe, so nearly perfected the Jermin device for card printing that I think the hope may be reasonably entertained that he will soon overcome the remaining obstacles.

While realizing the necessity for adhering closely to the official program, that it may be completed within the time allotted, I feel justi-

fied in referring briefly to a matter that may not be touched upon under any of the topics selected for discussion. I know that all our section directors are well informed as to the crops forming the principal staples of their respective sections, but I believe further attention to the subject is advisable, if not absolutely necessary, especially on the part of any who possibly may not yet have devoted that attention to the matter its importance demands. So far as I know, there does not exist any publication showing in graphic form, in sufficient detail, the areas devoted to the various crops. I believe that a part of the time of the section directors should be spent in the study of this matter, and, if necessary, data should be collected for the purpose of constructing maps showing the areas devoted to the several crops grown in their respective sections.

Not only should the areas devoted to the principal staples be accurately outlined, but those of many of the minor crops also. Suitable blank forms could be provided for the purpose of securing the needed data, which should be entered upon charts—a separate chart for each crop. These would also undoubtedly prove useful in studying the effects of the prevailing weather conditions upon the several crops. When the areas devoted to a particular crop are clearly marked out, any special information that may be desired respecting it at a critical stage in its development may be secured without calling upon the correspondents outside the area devoted to that staple. Take the tobacco crop in Maryland, for instance. Maryland does not rank high as a tobacco-producing State, yet there are some three or four counties in which tobacco has been the staple for generations; and if it were as extensively cultivated throughout the State as in these counties, the State would take high rank in the production of tobacco. In our work on the National Bulletin we find it of the utmost importance to have charted for each State on a map of the United States the percentage that State's product of any crop forms of the total product of all the States. This enables us to know what weight to give the statements respecting the condition of different crops as they come from the different sections. Take cotton for an example. Texas produces from 25 to 30 per cent of all that is grown in the United States, while some of the other States in the cotton belt make only about 5 per cent or less. We must exercise careful discrimination in weighting the several statements in the preparation of the general summary, the publication of which is now so eagerly awaited on Tuesday by those interested in crop production. And the section director should be very careful that his summary, which helps to guide the officials at the central office, should most correctly represent the conditions in his territory. It is to be hoped that the agricultural bulletins of the Twelfth Census will contain data in such detail as to afford our officials material that will prove adequate for such work without rendering the collection of additional data necessary. As soon as the agricultural bulletins of the Twelfth Census are issued effort will be made to have them supplied to all section centers.

One other matter before concluding. At every previous convention the importance of inspecting voluntary stations has formed one of the topics for discussion. I am glad to be able to say that initial steps looking to the general inspection of voluntary stations have recently been taken, and for the first time in the history of the Bureau section directors have been allotted small sums with which to defray personal expenses while making inspections. The sum allotted is not sufficient to enable each director to inspect all his stations, but with a moderate

allowance annually the whole field will be covered in a few years, and then a most important work will have been accomplished. Thus, in this matter, as in many others of importance, we are gradually but surely accomplishing the desirable ends suggested and considered at our Weather Bureau conventions.

SHOULD THE MONTHLY REPORTS OF THE CLIMATE AND CROP SECTIONS CONTAIN ONLY ORIGINAL MATTER?

By Mr. G. A. Loveland, *Lincoln, Nebr.*

Whether the monthly reports of the climate and crop sections should contain only original matter depends somewhat upon the scope or purpose of the reports.

The tables furnish in a very compact and complete form the statistical data, and the charts graphically portray the distribution of the precipitation and temperature. The text supplements these by summarizing the conditions of the month for the section, both as regards meteorologically and agriculturally. These summaries are important and should not be too brief.

If the purpose of the publication is only to record a history of the weather month by month, then the plan is completed when the above is included. If, however, the object of the publication is to instruct as well as chronicle events, and to explain the unusual occurrences recorded whenever possible, its field is wonderfully broadened and it becomes a more ambitious monthly; perhaps, too ambitious for the time the section director is expected to spend on editorial work. Starting with the premise that some portion of the space occupied by text shall be reserved for an article containing information on some other subject than the month's weather or crops. There is no question but such an article would be better if original matter when possible, and it is about equally sure that the section director will not have sufficient time to prepare as many special studies as such a plan would require. Then he must resort to contributed articles or clippings. There is small prospect of receiving contributed articles from voluntary observers. The notes on the reports at the end of the month are about all that can be expected, and these, unless they record something very exceptional, are best used by the section director in preparing the summary. The voluntary observers are interested principally in the records of their own offices, and few of them have the data, if they have the time, to study general meteorology or even the climatology of the section. However, they would one and all thoroughly appreciate anything of this kind that might be printed in the monthly report.

The records amassed in each section afford ample material for investigation and study, and their compilation in such shape as to render them more available and valuable to the public is an important duty. This work can be done with peculiar effectiveness by the section director. No other person has like opportunities for obtaining information as to the climate and crops of the section. The people of the section will appreciate the results of an intelligent study of these records. Attractively presented in the monthly reports which will become an educating factor in the section and probably beyond its limits. If it is impossible to obtain worthy original matter, there seems to me to be no objection to reprinting an article or an abstract of an article

on some pertinent subject. It seems that to have an article of a general nature, either of original matter or a clipping, will increase the value of the monthly report.

Mr. JENNINGS. The monthly climate and crop bulletin, I believe, can be made of considerably more value to the section in which it is published and which it represents if judicious selection be made of articles that can be utilized in that section. The Kansas Experiment Station issues a number of very practical bulletins. Last fall I quoted an extract from one of its bulletins regarding the soy bean. This spring in some of our southeastern counties the only crop that withstood the drought was the soy bean. The farmers had sent to the experiment station and obtained the seed, after having seen the notice in the monthly bulletin. There was a practical benefit. Some of the farmers might not have known anything about this soy bean if they had not seen this unoriginal article in the bulletin. We copied at one time, I think from the Arkansas section, an article that proved of general utility in the southern part of our State. The value of the bulletin can undoubtedly be enhanced by introducing judiciously selected matter from outside sources.

SHOULD THE REMARKS OF CLIMATE AND CROP CORRESPONDENTS BE PUBLISHED IN THE WEEKLY BULLETINS?

By Mr. S. W. GLENN, *Huron, S. Dak.*

My views on this question are based on sixteen years' experience in climate and crop service work in Dakota Territory and the State of South Dakota. They should not be considered as criticisms of the bulletins of other sections. We all have the same object in view—to make our work of the greatest benefit to as great a number of general interests as possible. An exchange of views on this subject can do no harm and may result in much good.

I consider the weekly climate and crop bulletin the most important publication issued by the Bureau, and hold the view that it should meet, as far as practicable, the requirements of all interests that may be served by a knowledge of the condition and progress of crops from week to week. It seems to me that without some reference, both specific and general, to the remarks of correspondents, whether by literal publication of individual reports or by brief synoptic statements, the bulletin would hardly be what its title implies. If the publication were entitled "Climate and crop summary," a general statement of conditions and progress probably would be sufficient and might satisfactorily meet the demands of interests affected only by the total volume of crop production, such as boards of trade, cotton exchanges, chambers of commerce, railway companies, commission houses, and like extensive interests. These are generally well posted on the average production of the several crops grown in the different States and are accustomed to making estimates based on logical deductions and precedent lines of computation without regard to local limitations. Considered from the viewpoint of economy of time and labor, a matter of great importance to all section directors, the omission of the remarks of correspondents would doubtless be desirable.

However, for reasons later set forth, I believe such omission would affect adversely the present popularity and far-reaching benefits of the

bulletins, especially of those issued west of the Mississippi River. Aside from the extensive interests mentioned, there are many others that are served by a knowledge of local conditions, such as wholesale establishments in all lines of trade, farm-machinery manufactories, lumber associations, produce dealers, trust and banking institutions having investments in farm securities, packing houses, the crop correspondents themselves, and, as regards our section of the country, the multitude that is constantly looking with hope toward the golden West. Experience has shown that very many of these have interests of local as well as general concern, and hence desire to follow the progress of crops from week to week, as affected by local conditions.

The division of the South Dakota bulletin into sections, a change from the former method of arranging the county reports alphabetically, regardless of location, was due to the increasing demand for local crop information. The character of the demands largely influenced the arrangement of the different sections, with special regard to topography, natural drainage, average precipitation, and adaptability of the soil to the production of the different crops. Not three months ago the Huron office received from one of the most extensive associations of its kind in the United States an application to be supplied weekly with 75 copies of the bulletin. The secretary later officially expressed the appreciation of the members, and spoke of the great value of the bulletins to them. Inquiries from other sources for local data have been frequent. Home seekers and men looking for business locations have informed me that their selection was largely determined by information received from the bulletin. Traveling agents of commercial houses are, for obvious reasons, frequently desirous of knowing the crop conditions prevailing in limited portions of the State.

Without the hearty, intelligent cooperation of crop correspondents the issue of the bulletin would be impossible. Many correspondents, who are farmers, not enjoying the convenience of rural free delivery, have at times to discommode themselves in order to mail their reports promptly, and I have good reason to believe that, in some instances, the desire to have their county represented has been the prime motive for their regularity. Furthermore, I am satisfied that the elimination of correspondents' remarks would tend to result, not only in irregularity of reports, but also in lack of interest on the part of correspondents, and hence a possible inadequacy of information. During the present season I adopted, for a time, the plan of omitting a county when the reports received were not sufficient to justify a concise statement of the conditions existing, especially when the conditions of the preceding week were of an uncertain nature, requiring full reports in order properly to set forth the changes of the current week. In nearly all instances such omission resulted in a very satisfactory quota of reports from the omitted county for the ensuing week. This, it seems to me, is positive evidence that the correspondents—the strongest factor in the crop bulletin work—desire to see their counties specifically referred to.

There is another reason, though remotely related to the existing general popularity of the bulletins, that should be considered. The individual interests affected by crop conditions, whether local or general, may be so great that a question as to the accuracy of the general summary will arise, and no better opportunity for prompt and ample verification of the general statement can be afforded than the reports by counties.

The conditions existing and the facilities afforded for collecting information may, and no doubt do, differ in the different States, and the different methods adopted for presenting the reports of correspondents are no doubt due to these considerations. In some States not only the literal remarks of the correspondent, but his name and post-office address, are printed, in some cases in rotation, because of limited space. This is a compliment which every correspondent richly deserves. However, it is in some cases impracticable, certainly so in South Dakota, where there are nearly 500 correspondents.

In the matter of securing and retaining correspondents the synoptic method of presenting county reports has been followed in South Dakota for a number of years with very gratifying success. I have yet to learn of any correspondent having been influenced to report from any motive other than the very laudable one of a general desire to assist in the work, aside from the personal one of having his county represented. For these reasons, as well as for general utility and accurate presentation of crop conditions existing from week to week, I am in favor of the synoptic method of publishing the reports of correspondents, the information being deduced from a careful and impartial consideration of all reports received.

If the demand exists for information of a more local character than can be fully met by a general summary, then the publication of the remarks of correspondents in some form is necessary. Assuming this to be the case, it would seem to be important that some uniform method of publication in this particular should be adopted.

DISCUSSION.

Mr. C. F. VON HERRMANN. Probably most section directors will concur in the views so well expressed by Mr. Glenn that the remarks of crop correspondents are a necessary adjunct to the bulletin. My own inclination is to file a dissenting opinion. While not quite favoring the total exclusion of remarks, I think they should not be made the chief feature of the bulletin. The object of the weekly crop bulletin is to present a general view of the condition and progress of crops as influenced by the meteorological elements over the limited area of a single State, eliminating minor irregularities resulting from differences in soils, methods of cultivation, original qualities of the seeds, etc. For this purpose a large number of correspondents is required as a basis for the preparation of a clear, comprehensive summary which shall truly represent the prevailing conditions. Now, North Carolina has 400 reporters, Texas 800. It is in most instances impossible to print the remarks from more than 40 to 70 places each week, and therefore the general practice is to adopt the method of rotation. Generally the remarks of any one correspondent may appear two or three times during a season. Considering the brevity and very general nature of the information furnished by correspondents it appears that this method fails to give details sufficiently definite to be of value for business purposes except in rare instances. To print the remarks from the same set of places regularly each week would discriminate against other points from which reports might be equally valuable to the public. The impression that it is necessary to print remarks to keep up interest in the work, in my opinion, is a mistaken one.

Most of our crop correspondents are practical farmers, and very properly so. The welfare of the farmer is so dependent on the influ-

ence of the weather that his so-called "personal equation" is very large. Bright skies and April showers place everything in a rosy light, while too much rain and weeds make every farmer, for the time being, a pessimist. In saying this I disclaim any intention to censure the work of crop correspondents, which indeed is indispensable and admirably suited for our purpose, but only to indicate that considerable experience and care in the preparation of a summary is necessary to avoid errors from this source. Readers of the bulletin may not possess the necessary discrimination. The crop bulletin should consist chiefly of a discussion of the effects of previous weather conditions which can only be properly treated by the expert in the summary.

The distribution of the crop bulletins is largely increased through the medium of the public press. The fifty or more newspapers in North Carolina that publish the bulletin do not repeat the remarks. Some newspapers in the larger cities may print the entire bulletin, but the country papers can not afford to do so. If chief attention is paid to the preparation of a satisfactory summary the reports of crop correspondents the summary will naturally receive more careful consideration. However, I think the form of bulletin generally adopted—a comprehensive summary followed by some selected remarks—is very suitable and I do not advocate a change. These simple considerations lead me to believe that the form of the Maryland and Delaware bulletin is the best.

The CHAIRMAN. The model bulletin, in my opinion, is one containing a comprehensive summary of weather and crop conditions, supplemented by data and remarks from as many correspondents as it may be possible to publish. I should consider the national bulletin not nearly so complete and valuable if the telegraphic summaries from State section centers were omitted, and they bear exactly the same relation to the national bulletin as the reports of the individual crop correspondents do to the local bulletin.

IS IT ADVISABLE TO DISTRIBUTE THE NIGHT FORECASTS BY THE RURAL FREE DELIVERY?

By Mr. M. E. BLYSTONE, *Springfield, Ill.*

In determining the desirability of distributing evening as compared with morning forecasts over rural free-delivery routes two principal things are to be considered: First, the comparative accuracy of these forecasts, and, second, the facilities offered by the rural free-delivery service for their distribution throughout farming communities. The first of these it is not my purpose to discuss at any length, as I have not at hand the percentage of verification of the two classes of forecasts, and I will only say that if the evening forecasts are as accurate as the morning forecasts they would seem to be the more valuable, in that they cover a period of forty-eight hours, while those of the morning cover a period of only thirty-six hours. But it will probably be urged that the more extended the period for which forecasts are made the less accurate they will be for the final portion of that period. This is undoubtedly true, and, since it is true, the forecast for the second twelve hours of the period will be more accurate than that for the third twelve hours. Whenever the time of mails is such as to permit it, carriers endeavor to start over their routes at a very early morning hour, and not infrequently the start is made as early as 6.30 o'clock.

If the carriers starting at this early hour can take the forecast with them, it can be made to reach the farmers over a large part of the route in time to enable them to plan the work of the day in accordance therewith, while if the carriers do not depart until 10 or 11 a. m. the farmers receive the forecast at such a late hour that its value for the day on which it is issued is greatly reduced. Such being the case, the forecast for the third twelve hours becomes the important one to the farmer, and the value of this must be compared with the second twelve hours of the evening forecast. The importance of having the forecast early in the day to which it relates is greater during the harvest season than at other times, but at all times farm work will be effected to a greater or less degree by a foreknowledge of probable conditions; but long before the morning forecast can reach him the farmer has planned the operations of the day and has them well under way.

The principal advantage in the distribution of evening forecasts is the completeness with which it can be made. Less than one-fourth of the post-offices in Illinois at which the rural free-delivery service has been established are able to take advantage of the opportunity to furnish the farming community with the forecast. With scarcely an exception the desire to aid in the work is expressed by postmasters, provided the forecast can be received early in the morning or at such time as to not delay the work of the post-office. In some instances the carriers start late enough to enable them to take the forecast, but the work of the post-office is such that the carriers can not undertake the distribution. I am led to believe, from the replies to my letters, that if the evening instead of the morning forecasts were sent out the limit of the territory covered by the forecast card would be nothing less than that of the rural free-delivery service itself. I have had some correspondence and conversation with officials of the Post-Office Department who are establishing and enlarging this service in Illinois, and I find that some of them are as enthusiastic for forecast distribution over rural free-delivery routes as are Weather Bureau officials themselves. I will not claim that the officials of the Post-Office Department are entirely disinterested in their enthusiasm. The rural free-delivery service is still in its infancy, and whatever may tend to popularize and strengthen it is rightly taken advantage of by those who believe in its value. Forecast distribution does this, and for that reason, as well as from the desire to promote the public welfare, all possible aid in this work is given to the Weather Bureau. It is hardly probable that sufficient importance is attached by post-office officials to the work to induce them to take it up at the expense of the postal service, nor can this be expected. The most serious objections offered by postmasters to delaying carriers until the morning forecast is received are found to be the necessity for the return of carriers in time to dispatch mail on outgoing trains and the bad condition of roads, which prevents them from making the return trip over their long routes at a reasonable hour. The former objection will always be effective at many post-offices, while ultimately, no doubt, the latter will be largely overcome by the improvement in roads, which it is hoped will attend the development of the rural free-delivery service. It will probably be a long time, however, before the improvement is very decided, and in States like Illinois, where much of the soil is of a nature that renders the construction of good roads a matter of enormous cost, this improvement will necessarily be slow. Another objection to delaying carriers that is frequently met is that farmers prefer to receive their morning

papers early rather than to have the carriers wait until they can receive the forecast. The evening forecast is published in the morning papers, and with it there is frequently published a large amount of additional weather information in the way of synopses or tabular data, which appears to be as satisfactory to the farmers as the morning forecast would be. Indeed, the morning papers generally publish this information so completely and satisfactorily that, where they have a large circulation, I believe the forecast received in this way would serve the same purpose as if received by card, and take away the necessity for the latter method of distribution. In view of the fact that the weather forecasts are so highly appreciated, it would seem advisable to take the fullest possible advantage of this excellent opportunity to increase both the usefulness and the popularity of the service by using the evening forecasts. Wherever the morning forecast could be distributed at as early an hour as the evening forecast the former is, of course, of the greater value. At many places the time of arrival of mails is such that the carriers are compelled to start over their routes at a late hour, giving ample time for the morning forecast to be received and the cards stamped, and where such is the case it is desirable to continue to send out the morning forecast.

DISCUSSION.

Mr. SCHNEIDER. Michigan conditions are the basis for all my statements and conclusions, and these conditions, I suppose, are quite similar to those of most districts east of the Mississippi River.

On August 1, 1901, Michigan had 234 rural mail routes in operation, supplying on an average about 100 boxes each, or, roughly, about 23,400 families in all. Very soon after each route was established, the Lansing weather bureau office corresponded with the various postmasters for the purpose of enlisting their cooperation in rural forecast distribution, providing that the leaving time of the rural mail carrier was not earlier than the receipt of the a. m. forecast; if the leaving time was too early, a hope was expressed that the carrier could be held until about 10 a. m., at least during the planting, growing, and harvesting seasons. At present less than 100 routes are supplied with daily forecasts almost solely because the carriers leave their home offices before the time of receiving the a. m. forecast, which generally occurs between 9.30 and 10 a. m., central standard, or 90th meridian time; this standard is the time in use in Michigan. On some routes where it has been possible to distribute the a. m. forecasts the volume of regular business has gradually increased until it is a hardship for the carrier, an inconvenience to the postal authorities, and a delay of mail delivery to hold the carriers until about 10 a. m., and in a few cases the forecast distribution has been discontinued to enable the carrier to make an earlier start.

Along routes where there is no rural forecast distribution, the reason is almost invariably found in the comparative lateness of the receipt of the morning forecast, the postmasters deeming it impracticable to hold the carriers two hours after the rest of the business world has begun its work. In a very few cases postmasters have entirely refused their cooperation, but usually they express a strong desire to secure the rural forecast service, believing that their rural patrons will greatly appreciate it.

Still another condition which is worthy of note is the fact that the circulation of many Michigan and Chicago daily newspapers is so

arranged that papers reach many of the rural mail termini early enough to be sent over the route; these papers all contain the p. m. forecast, and the question has often been asked by those interested why the Bureau does not use that forecast for rural route dissemination.

Present conditions (and probably future ones also) are: The a. m. forecast is issued too late for general rural dissemination. It is improbable that the leaving time of carriers will ever become generally as late as 10 a. m., a majority of them now leave considerably earlier.

In considering the advisability of using the p. m. forecast, it must be remembered that there is an almost settled policy in the Bureau that it shall not be used except for morning newspaper publication, and that its distribution is now largely accomplished through the medium of the press dispatches; it is also an administrative consideration that, except for the Washington a. m. and the two Pacific coast districts, the a. m. and the p. m. forecasts emanate from different offices; so that if the p. m. forecast were telegraphed out to a large number of post-offices for rural distribution it would entail much additional labor and expense to the Government. Nevertheless the discussion resolves itself into the question of whether, under the present conditions, the p. m. forecast shall or shall not be used and its solution will determine whether a large number of farmers shall or shall not be supplied with daily forecasts. I strongly favor a solution which will place the p. m. forecasts at the disposal of section directors for rural dissemination, because to the agriculturist, the coming weather is a matter of prime importance; he meets it face to face every day and all the day; there is not an operation in the field, garden, orchard, or pasture which is not modified, if not controlled, by the state of the weather.

The rural mail route has put an entirely new light on the matter of dissemination of forecasts and warnings in the country. It is a new condition, the importance of which is rapidly increasing, and it is necessary for the Weather Bureau to rise to the opportunity that now presents itself and give the agriculturist the benefit of its work.

In closing, a word may be added in answer to the possible objection regarding the confusion of the two forecasts which really appear before the public but a few hours apart. If the Bureau can give its p. m. forecast to the public through the morning newspaper, which reaches millions of readers, why should it not be used for the benefit of the farmer along the rural free-delivery mail routes until some new system is devised that will give the public only one stated forecast early each day, and which will serve both rural and urban interests alike.

The CHAIRMAN. We could reach thousands of homes in the rural districts with the night forecasts that can not be served with those prepared in the morning. Our chief difficulty in utilizing the rural free-delivery service in the dissemination of the morning forecast is due to the early departure of the carriers—before we can reach them with the telegrams. I am confident that the night forecasts would be gratefully received, and that they would prove valuable; but there are objections to using them for this purpose. As a rule, the telegraph offices in the smaller towns, from which the carriers depart, are not open until 8 a. m., so that the night forecast can not be made to reach the distributing point very much earlier than the morning forecast, which is based upon information received twelve hours later.

I would like to state that the hearty cooperation of the Post-Office Department in this work is consistent with its action in the past in other matters regarding the work of the Weather Bureau. A carrier

in a Western State once refused to receive the forecast cards, and the matter was reported to Mr. Machen. He at once dictated a telegram to the postmaster directing that if the carrier persisted in refusing to receive and distribute the forecasts, he be suspended from duty. We had no further trouble.

HOW MANY CLIMATE AND CROP CORRESPONDENTS ARE REQUIRED TO MEET FULLY THE NEEDS OF THE BUREAU IN ITS CLIMATE AND CROP SERVICE?

By Mr. R. G. Allen, *Ithaca, N. Y.*

The number of climate and crop correspondents in each State should be sufficient at all times to insure receipt of reports from several well-selected points in each county. In New York it is found that the number of reports received during the planting, growing, and harvesting of crops is much less than at other times of the year, as the farmers, from whom correspondents are mostly selected, are too busy at that season to attend closely to the regular mailing of the cards. But it is at this time that many reports are required, as the uneven distribution of summer precipitation results in different crop conditions in adjacent sections. Local showers may greatly revive crops in some sections of a county while severe drought may continue for weeks in other sections of the same county. For this and other reasons, it appears to be necessary, in writing a bulletin which will reflect the true conditions, to receive reports each week from many parts of each county.

The number of reports each week should be just as many as the writer of the crop bulletin can digest; a larger number does not appear to be advisable, as the time consumed reading the additional cards could be given to better advantage to the preparation of the general summary. In order to receive weekly 250 to 300 cards, which are sufficient for the preparation of an accurate bulletin of a large State, it is necessary to have a list of 500 to 600 correspondents.

DISCUSSION.

Mr. Hackett. The more reports we receive, provided we can read and thoroughly digest them, the more accurate will be our summaries, and it seems to me that the controlling factor in selecting crop correspondents should be to get as many reports as we can advantageously use in preparing the bulletin and summary. In Missouri there are about 500 correspondents, representing 114 counties, and we receive from 250 to 400 reports weekly. If a special request is sent out, nearly all correspondents reply, and their reports I find ample for all needs. In important agricultural States I think there should be three or more correspondents for every county. It would probably be an advantage in some counties, where there is a great diversity of crops, or where special attention is given to some particular crop—fruit, for instance—to secure one or two observers in that county to report on that crop and nothing else. I find that a very good plan, as it gives me the advantage of the judgment of people who are in a position to know more about a particular crop and are better able to judge of its progress, the injurious effects and conditions, than those who are not making a special study of it.

The CHAIRMAN. I do not think anyone can handle three or four hundred reports and accurately sum up the situation regarding each crop from memory. It is absolutely necessary to jot down the facts on charts, one for each crop, and after all the information has been charted the section director can discuss intelligently the condition of each crop. I think that is the plan of all our section directors. If it is not, I will say that the Central Office will be glad to provide a base map of each State on a sufficiently large scale to enable the section director to plot thereon the conditions indicated by the reports.

As to the necessary number of climate and crop correspondents, I know there is great diversity of opinion. I think the total number of our crop correspondents could be increased with advantage. Our lists for all States aggregate about 14,000. I am disposed to think that this number should be increased 25 per cent, and, furthermore, that there should be a reserve list amounting to 25 or 30 per cent of the active list, to be called upon as occasion may require. The distribution of the correspondents is a matter of much importance.

Mr. CHURCH. I had some acquaintance with crop correspondents before I went into the Department of Agriculture. It occurs to me that there is one factor that might be considered. The number and value of the reports of crop correspondents seems to me to be very largely governed by their geographic distribution. In the large farming counties in the West, if the section director can so distribute his correspondents that every part of the county will be represented, I think the worth of their work will be largely enhanced. It is better to have a county divided into three districts and a responsible and intelligent correspondent in each one of these districts, making three, than to have three correspondents from one school district, for instance.

PHENOLOGICAL DATA.

By Mr. J. WARREN SMITH, *Columbus, Ohio.*

To show that there is need for such data and the value and importance of keeping notes on the dates of planting, growth of crops, and harvesting, I wish to quote from a recent letter from Prof. Chas. E. Thorne, director of the agricultural experiment station, Wooster, Ohio:

Experimental sowings of wheat were made last fall by this station at Wooster and Strongsville, 40 miles north, on dates a week apart, through September and into October. The present condition of the wheat shows a destructive attack of hessian fly, occurring between September 8 and 25 at Strongsville and between the 7th and 28th at Wooster, the severest injury occurring to wheat sown between the 15th and 22d. Wheat sown September 28 to October 5 at both places now promises an abundant yield, as does wheat sown on October 4 and 5 on the State University farm at Columbus, where no earlier sowings were made. I am informed, however, that wheat sown October 8 to 10 in Gallia County was severely injured.

I find, on referring to the report of the Michigan board of agriculture for 1877, that Prof. A. J. Cook, then of the Michigan Agricultural College, gave September 20 as the date of probable earliest safety in his latitude, deducing this date from a consensus of observations running back half a century and made chiefly by Fitch, of New York, and himself, but he called attention to exceptions to this date noted during the attack of the fly in Michigan, which had extended from 1875 to 1877, exceptions in which the date named seemed not to have been sufficiently late to avoid injurious attacks; and Dr. James Fletches, Dominion entomologist of Canada, has recently recommended that sowing be delayed in Ontario until the last week of September. It thus appears that the date of safety may be between three and four weeks later for the latitude of southern Ohio than for that of Ontario and Michigan, 4 degrees farther north, but that this date is liable to vary in different seasons.

What seems to be needed is some natural phenomenon that will mark the transition from summer to autumn and by which the farmer may be guided in his seeding. Frost is such a phenomenon, and frost may possibly have the further

useful effect of destroying the eggs or young larvæ of the fly. I fail to find records of observations on this point. But last year the frost failed to come, and all over Ohio the corn crop matured and went into shock unfrosted, something I have never observed before, although it may have occurred.

There is an old farmers' rule that corn should be planted when the white oak leaves are as large as a squirrel's ear. This gives a date which moves backward or forward with the earliness or lateness of the season, and also gives a phenomenon by which we may mark the progress of the season from south to north. Could we have observations on this point and on some similar phenomenon in the fall, such as the first coloring of the sugar-maple leaves, care being taken in this case to mark the general appearance of the autumn coloring and not some isolated instance which might be due to accidental causes, we might trace the backward progress of the summer across the State.

Such observations as these, extended through a series of years, would give information of great practical value.

We also need, and that at once, reports from careful observers respecting the condition of wheat sown at different dates last fall, for, much as has been written about the date of sowing to avoid the attack of the fly, it is evident that we as yet know but little about the matter.

This letter not only shows the need for such data, but indicates the appreciation of the writer of the valuable and complete system that the Bureau has in operation in connection with its observers and correspondents.

I published this letter in full in our monthly report for April, and to date have received phenological data from just one observer.

I believe that others have such memoranda, and it should be one of the duties of the section directors, in inspecting voluntary stations, to ascertain whether the observer or some other person in the neighborhood has not been keeping them.

To secure such information is, to my mind, one of the advantages of inspection, and I believe that the director should remain long enough in a neighborhood to secure information about the crops, the neighborhood, the topography of the district, and such weather and climatological data as may be available. Then, at his first opportunity, he should correlate the conditions and results. Mistakes may be made and incorrect conclusions drawn, but in time valuable data will be accumulated.

To encourage observers and correspondents to record phenological data a suitable form should be prepared and sent out to them each year. It may not be desirable to have this form cover more than two or three of the principal crops of the neighborhood, together with the leafing and flowering of certain trees, as suggested by Professor Thorne.

For example: The data for corn should show the date of planting, of appearance above the ground, of one intermediate stage of its growth, of tasseling, shooting, and ripening. Space should be given to record the attendant weather, and for noting any well-defined reason for unusually early or late dates.

All observers would not have the time for this work, but I am sure that a sufficient number in each State could easily be secured to make the results very valuable.

DISCUSSION.

The CHAIRMAN. I consider this a very interesting subject. So far as I know phenological records are very scarce and fragmentary. A few years ago an effort to gather some information along this line was made, but it was not rewarded as fully as we anticipated. I was much surprised to learn that the agricultural experiment stations at that time were not able to materially help us. I fully agree with Mr. Smith that some blank form or diary should be provided, and its use

encouraged among our voluntary observers and crop correspondents. As to the character of the form to be used, I am not fully satisfied that we have yet devoted sufficient attention to the matter to enable us to determine just what may be best, but by inviting suggestions we can prepare a form that will doubtless meet the requirements.

CLIMATOLOGICAL STUDIES WITH REFERENCE TO THE CROPS OF THE SEVERAL SECTIONS.

By Mr. C. F. von Herrmann, *Raleigh, N. C.*

The study of climate in relation to agriculture involves chiefly an investigation of the influence of the meteorological elements upon the structure and growth of plants. This problem is an extremely complex one. It is difficult, indeed often impossible, to distinguish sharply between the effects of climate and those modifications which are brought about by the varying physical and chemical nature of the soil, the action of the lower forms of life, or the work of man. The object of the agriculturist is to improve the quality and the yield of crops by suitable application of fertilizers, proper modes of culture, and by constant selection of the best seeds and the introduction of new and improved varieties. The favorable or adverse influence of the weather, however, so often completely controls the results of the farmer's efforts that no subject in the whole domain of agriculture is of greater importance than the study of climate and crops. The aim of this paper is not to discuss the intricate relation of climate to vegetation in general, but rather to point out the methods which may be most suitably employed by the Bureau in practical investigations of crop conditions and yields, and the direction in which voluntary observers may be persuaded to extend their work.

Plants reflect the influence of the meteorological elements in two ways. In the first place they possess a fixed, inherited habit of development, which is largely the result of the normal climate of the region to which they are indigenous or in which they have become acclimated. The influence of permanent climate only, not the changeable conditions of a season, has produced during past ages those variations in plant structure which, by natural selection, have developed the innumerable species now existing. On the other hand, every plant is immediately modified during a single season of growth by varying weather conditions, an excess or deficiency of moisture, frost, or heat, which interferes with the efforts of the plant to complete its growth and mature its seeds in the normal way. From this point of view there are two lines of investigation open to us: the one includes the microscopic examination of plant structure and the distribution of vegetation over the globe which depend on climate, and the other the study of economic crops as affected by the weather from day to day.

Climate has produced many special adaptations in the minute structure of plants, such as the wonderful provisions for regulating the loss of water by transpiration, or of lessening the influence of intense insolation, which are used by the botanists as the criterion for the classification of plants on a physiological basis, and are important in the study of the geographical distribution of vegetation. As this is preeminently an age of specialists, the study of plant anatomy and plant geography must be left to the botanist, since these subjects require a more extended knowledge of botany than members of the Weather Bureau may reasonably be expected to possess. Indeed, plant structure and the relationship of the zones of vegetation to cli-

mate have been relatively well studied, and the literature of the subject, especially in the German language, is very full. The most satisfactory treatment of this subject and the finest collection of illustrations ever published will be found in the recent elegant and authoritative work by A. F. W. Schimper.

By the term "weather" is understood the phenomena presented at a definite time by all the meteorological elements acting together. Our efforts are directed toward establishing some definite correlation between the growth and yield of crops and the vicissitudes of weather which they undergo from day to day. We know that growth depends upon temperature; for each species there is a maximum and a minimum degree, beyond which the plant perishes, and an optimum, which secures the most vigorous growth; light causes assimilation and enables the chlorophyl to decompose the carbon dioxid of the air; water acts as the medium by which food is taken from the soil; a plant secures its best development when each factor reaches a maximum of favorable influence at the proper moment of time. The most practical work of the climate and crop sections will be directed toward extending our knowledge of these phenomena. In fact, the weekly crop bulletins published by every section and by the national service, which have become so important a feature of our work, are the results of efforts in this line.

The study of climate in relation to the crops of the several sections may be conducted by examining, in comparison with prevailing climate, the statistical material in regard to crop conditions, and by cooperating with or adopting the methods of the agricultural experiment stations in the investigation of special crops.

1. The information furnished by crop correspondents which is utilized in the preparation of the weekly bulletins is too general and vague for strictly scientific purposes, however valuable it may be for immediate business interests. Information of greater detail by more skillful observers is required. The statistical branch of the Department of Agriculture publishes during the growing season monthly statements of the condition of every important crop for each State in percentages. The percentage statement for a crop in the limited area of a single State represents largely the result of previous weather conditions in as exact a form as can at present be attained. By taking the percentage condition of a crop for each month for a series of years and studying the figures in connection with the temperature, precipitation and sunshine records, and the departures from the normal at all regular and voluntary stations, certainly some definite laws of value to agriculture will be obtained. This is a more detailed and extended method than the mere comparison of crop yields with the climatic conditions for a year.

2. The sections certainly should cooperate with the agricultural experiment stations and adopt the method of studying the cultivation of plants upon special plats. For this purpose it is not necessary that section directors engage directly in raising crops, but only that information be sought from those who are practically and successfully growing the crops under investigation. Taking up a special crop, it will be easy with our present printing appliances to prepare a schedule of questions covering every phase in the growth and development of that crop, its useful variations under different climatic conditions, etc., to be sent to as large a number of well-known growers as possible. The answers should be studied in the light of knowledge and experience gained from every available source. Some years ago

the Weather Bureau employed several scientific men on the staffs of the experiment stations to make special reports on single crops, and I recall particularly an excellent bulletin on the Climatology of the Cotton Plant, by Prof. P. H. Mell, of Alabama, which will indicate what might be accomplished in this way. The method here outlined would require that section directors select special subjects in connection with crops for investigation.

For scientific studies more than the elements of temperature and precipitation are required, but at present it does not seem advisable to increase the instrumental equipment of voluntary observers. They may be persuaded, however, to extend their work by undertaking the study of wild and cultivated plants in relation with the records of temperature, precipitation, frost, etc., or phenology. A detailed record for a selected list of plants, of the time of sprouting, leafing, and flowering, of the ripening of the fruit, time and yield of the harvest, would help to lessen our ignorance of the laws of plant life.

In conclusion, mention may be made of a few of the innumerable problems that suggest themselves for solution. We must ascertain the proper climatic conditions that will assure the largest and best yield of every crop and be able to predict the time and character of the harvest; whether plants can be successfully grown in localities where it is desirable to introduce them; what variations climate produces in the specific qualities which render plants useful, for instance, in the saccharinity of sorghum or of beets; in what section shall we be able to develop flax with sufficient pliability of fiber, or tobacco with the most desirable color and flavor. The protection of fruits in orchards or in transit is part of the problem. Finally, considering the innumerable species of plants in existence, there is the possibility of largely ncreasing the number of those which are economically useful to man.

MARYLAND CLIMATOLOGICAL STUDIES.

By Mr. O. L. Fassig, Ph. D., *Baltimore, Md.*

The Maryland State Weather Service was organized in 1891 by the present director, Prof. William B. Clark, of the Johns Hopkins University. It is conducted under the joint auspices of the Johns Hopkins University, the United States Weather Bureau, and the Maryland Agricultural College. In 1896 the Maryland and Delaware section of the climate and crop service of the United States Weather Bureau was established, with headquarters at Baltimore. The director of the State service, being thus relieved of the labor and expense of collecting and publishing weather and crop data, outlined a new plan of work, which is now being carried on with the cooperation of the national Bureau, under the direction of Prof. Willis L. Moore.

The director of the State service is also State geologist. The provisions of the legislative acts establishing these services are broad in their scope, while the appropriations are ample under the circumstances. Taken together they afford an opportunity for a thorough survey of the physical characteristics and the natural resources of the State.

It is the purpose of the State service to devote its energies in the future chiefly to the publication of special reports on the climatology of the State, giving to the term climatology a very broad interpretation. Special volumes will be prepared on agricultural and medical

climatology and the more closely related phases of physiography, hydrography, forestry, and soil conditions.

The results already accomplished have been made possible, with the moderate State appropriation available, by the broad-minded policy of cooperation between State and nation when working along similar lines. The director has on various occasions publicly expressed his indebtedness to the Secretary of Agriculture and the Chief of the Weather Bureau for their great personal interest in the work done in Maryland. The first fruits of this cooperation are embodied in Volume I of the new series of the Maryland State Weather Service Reports. The volume is doubtless familiar to you all. The extent of the cooperation between State and national bureaus may be judged by the fact that three of the four contributions which go to make up the volume were prepared by members of the Weather Bureau. The volume was planned and published by the director of the State service, while by far the larger portion of it was written under the direction of the Chief of the United States Weather Bureau.

The volume is devoted to a description of the physiographic features of Maryland, by Dr. Cleveland Abbe, jr.; to a general presentation of the aims and methods of meteorological work, by Prof. Cleveland Abbe, sr.; to an historical sketch of the progress of meteorological work in Maryland, by the speaker, and to an outline of our present knowledge of the meteorology and climatology of Maryland, in which Mr. F. J. Walz has presented an elaborate reduction and discussion of Maryland climatic data available at the time.

Other volumes of the same general character are to follow. Volume II, as at present outlined, will be devoted to the reduction and discussion of the Baltimore observations of the United States Weather Bureau from the date of the estabiishment of the station, in 1871, to the close of the year 1900, a period of thirty years. Considerable work has already been done by the speaker upon this memoir on the climate of Baltimore. Much time and labor will be required to complete it. An attempt will be made to present, in attractive form, the results of the long series of accurate observations made at great expense by the National Government. The volume will contain, probably in addition, a memoir upon the average distribution of atmospheric pressure over the globe and its influence upon the weather of the Middle Atlantic States.

The State geologist has begun the publication of a series of county reports upon the geology and physical features of Maryland. A separate volume is to be devoted to each of the twenty-three counties of the State. Each volume of this series is to contain a chapter upon the climate of the county under consideration. The volume on Allegany County appeared some months ago. The climatological data for Garrett County, in the extreme western part of the State, and for Cecil County, in the extreme northeastern portion, are now being reduced and discussed for early publication. These county climatological studies, should the series be completed, will probably be reprinted and gathered into a future volume of the Maryland State Weather Service Reports.

State weather services have now been in existence for periods ranging from eight or ten years to twenty and more years. In many States the period of observation at one or more stations extends much farther back, affording excellent material for contributions to the study of local climates. The time is now ripe for collecting and intelligently discussing this vast fund of valuable observational

material and placing the results within reach of the people. This is what is being done in Maryland. We are fortunate in being able to publish results in an attractive form, the graphic arts figuring largely in the composition of the reports. Being addressed primarily to the general public, they are mostly free from purely technical forms of expression or manner of treatment.

Valuable work can be done along these lines at many section centers, even without a special fund for publication. The preliminary work of collecting and discussing the data requires time, but there is little or no additional expense connected with it. While but little space is available in the columns of our monthly climate and crop reports for the publication of local climatological studies, still many valuable contributions of an original character may be made possible in this manner by a judicious use of the few columns not filled with tabular matter or charts.

DISCUSSION.

F. J. Walz (Chicago, Ill.). A comprehensive study of the climatology of Maryland was undertaken by the writer in 1898-99, and the results published under the auspices of the Johns Hopkins Press in Vol. I of Maryland State Weather Service Reports, 1899.

As Dr. Fassig has given a complete outline of the work attempted at that time, as well as that contemplated along this line for the immediate future in the State of Maryland, I shall pass over that portion of the discussion and only attempt briefly an explanation of what was considered accomplished in those studies in the attainment of climatic knowledge of the State of Maryland.

The object of the studies and their publication was to set forth in a brief and concise way the climatic conditions of the State in its various physiographical divisions, and to give the information in such form as might prove attractive, and at the same time suitable to the needs of all desiring information regarding the climate and weather of Maryland. General facts were presented, as far as possible, and the results and deductions from the observations of weather elements were given, rather than a vast amount of tabulated records, tables being introduced only where it was deemed necessary to give in full such data as might be practically useful.

A little in the way of showing causation for the variations in climatic conditions was also attempted. The study was prepared under the following heads:

General Discussion.—Under this head were presented briefly the more important of the general laws involved in producing the climate of a place. The operation of the four main causes of the varied character of climate, namely, latitude, elevation, distance, and location with reference to the sea and prevailing winds.

Meteorology, or Weather.—Under this head were discussed the distribution, character, and movement of pressure areas.

Climate.—Under this head were described:

(1) The geographical location and physiographic features of the State, an intimate knowledge of which is necessary to the discussion and understanding of the climate of any section.

(2) The condition of the atmosphere in regard to heat and moisture for every portion and physiographic section of the State; that is, the normal temperature and rainfall, with the departures therefrom, and distribution geographically and chronologically.

METHODS OF SAVING TIME IN THE DISTRIBUTION OF FORECASTS.

By Mr. W. T. Blythe, *Indianapolis, Ind.*

The methods of saving time in the distribution of forecasts vary with the conditions existing at the several distributing stations, the kind of forecasts, the telegraphic, telephonic and mail facilities, and messenger service available.

For convenience in this discussion, and for the information of those who are not members of the Weather Bureau, it is deemed advisable to describe briefly the different kinds of forecasts issued and the several classes of stations. Daily forecasts are of two kinds, viz, State and local. State forecasts are those prepared to cover the general weather and temperature conditions in the State, as a whole, during the period named therein—not less than twenty-four hours, usually thirty-six, frequently forty-eight, and sometimes a period of greater length. Local forecasts differ from those made for the State only in that they are confined to the locality of the station at which or for which they are made.

Distributing stations may be classified as follows: Forecast district centers, forecast distributing centers, forecast display stations.

The United States is divided into seven forecast districts, the headquarters or central offices of which, named alphabetically, are: Boston, Mass.; Chicago, Ill.; Denver, Colo.; New Orleans, La.; Portland, Oreg.; San Francisco, Cal., and Washington, D. C. To each forecast district center is assigned a certain territory, embracing several States, and it is the duty of the official in charge or some other qualified member of the office force, designated by proper authority, to make daily forecasts for each State in his district. Copies of these State forecasts are sent by telegraph and telephone to all regular Weather Bureau stations in the States for which they are made, to such forecast display stations as can be reached with least delay direct from the district center, and to certain forecast distributing centers (to be described hereinafter); are furnished press associations and daily newspapers; by telephone to commercial exchanges and public institutions to be bulletined upon blackboards; printed upon the weather chart and, by the logotype process, on postal cards, for general distribution by messenger or mail for the benefit of the public.

Forecast distributing centers are stations designated as such by the Chief of Bureau because of their locality and superior telegraphic facilities. The service required at such stations is precisely the same as that at district centers, with this one exception, that the forecasts are not sent from them to other regular Weather Bureau stations. Forecast display stations are selected places where the postmaster, or some other public-spirited person, gratuitously cooperates with the Bureau by receiving forecasts, displaying weather and temperature flags, distributing copies printed upon postal cards by the logotype process, publishing them in the evening newspapers, and otherwise disseminating the information contained.

It is proper to state that, in addition to the distributing stations above mentioned, forecasts, State and local, are published daily upon weather charts and postal cards at nearly all Weather Bureau stations.

Accurate instrumental observations and correct deductions from the data obtained is the most important work of the Bureau, next to which is placing these deductions—forecasts—before the public, and

the object of this discussion is to determine how this work can be performed with the least possible delay. For the reasons stated in the beginning of this article it is obvious that no rule applicable to all stations of the same class can be used, therefore I shall content myself with an attempt to point out a few cases where more or less time may be saved by rearranging the details of the morning work at stations where State forecasts are prepared or distributed.

The Bureau properly holds each individual forecaster responsible for his work, and necessarily it is left to the discretion of the forecaster at what stage in the preparation of the study chart he begins to write forecasts. Naturally the official desires to obtain and have placed before him all available data, but it is believed that a saving of some time might be effected without decreasing the value of the forecasts if he was required to prepare them for distribution before writing the synopsis. In fact, experience, observation, and hearsay evidence as to the methods practiced in making the study charts at some stations, suggest the idea that officials who make forecasts might save both time and labor of the man who does the clerical work on the general chart by making it themselves. By so doing the existing and probable changes in weather conditions would be fixed in their minds while entering the data and drawing the lines, and thus the necessity for much further study would be avoided and a saving of time in filing messages for distribution would be effected.

Primarily the saving or loss of time in placing State forecasts on the wire at forecast distributing centers rests with the official in charge, who apportions the work of the station to his assistants, but the first actual, and not least important, labor in time saving should be performed by the messenger. This labor consists in the preparation of sets of blank messages containing the addresses of all display stations in that particular district. By arrangement with the proper telegraph official the addresses may be so grouped that each blank may contain several, and thus the number of forecast telegrams to be prepared can be materially reduced. A set of these blank messages should be prepared during the afternoon of each day for use on the following morning. At distributing centers, when the station force is sufficient to admit of such arrangement, considerable time may be saved by having a man, equipped with a set of skeleton telegrams and a logotype or other duplicating outfit, in the operating room of the telegraph office every morning to make copies of the State forecast and immediately file them for transmission to their several destinations. By this method copies of the forecast addressed to every display station in the district could be filed for transmission within a period ranging from five to ten minutes after its receipt, whereas if the message should take its regular course, even if "rushed," from ten to thirty minutes' time, dependent upon the distance between the telegraph and Weather Bureau offices, would be consumed in delivering the message and returning copies to the telegraph office.

The service of distributing copies of forecasts by ordinary mail and rural free delivery service at forecast display stations being performed by displaymen, who cooperate with the Bureau without compensation, promptness in handling forecasts thereat depends largely upon the interest taken by the individual displayman. Close attention to the needs of the displaymen on the part of the section center in furnishing supplies, writing courteous letters of inquiry regarding their needs, requesting them to suggest methods for the improvement and extension of the service, together with occasional visits by a repre-

sentative of the Bureau, are calculated to increase their interest in the work.

Much may be done in this regard also by furnishing the addressed forecast cards in packages containing one card only for each address on the displayman's list. The improved method in copying addresses recently introduced at most, if not all, distributing centers makes this not only possible without extra labor, but comparatively easy.

I repeat that it is not practicable to enumerate in this paper all instances where time may be saved during the preparation and distribution of forecasts, but it is hoped that the few pointed out may serve to illustrate what can be accomplished by systematizing the work at the several stations so that the whole time of every member of the office force may be profitably utilized during the "rush" morning hours, and to the end that the public may reap the benefit of our labors at the earliest possible moment.

DISCUSSION.

C. E. LINNEY: Mr. Blythe has practically covered the ground in his paper, but I wish to emphasize a few of the points which he gave.

You are all familiar with the manner of distribution by means of the logotype outfit and cards, also the other means of distribution after the telegram reaches the displayman, and I will not take up your time with a discussion of them, but wish to give you a few points on the method used at Chicago to secure rapid transmission of messages.

Several years ago, when we began to investigate the manner in which our telegrams were handled, we were sending the forecasts to the several section centers, which in turn sent the forecasts to the displaymen. We found that in a large number of instances telegrams from the section centers to the displaymen were sent from the section center back to Chicago, relayed there, and sent on to the displayman. This was especially the case with the near-by States—Illinois, Iowa, Wisconsin, Michigan, and Indiana. The loss of time ran from one to three hours. We then went to the Western Union officials with a complete list of displaymen and others receiving forecast messages within the Chicago district, and asked for the relay points on them. When these were received we prepared blanks accordingly, placing all points in each State which were relayed at the same point on one blank, and in some instances entire States were covered in this way. A duplicate set of these was furnished to the Western Union Company, with the information that we should begin to distribute messages after the plan at a certain date, which we did. If most of the points of a certain State to receive forecasts were relayed at one point, the message was written at the desk from dictation as the forecaster gave it, while if several blanks were required the messages were run off on the milliograph. We have thus been able to handle over 600 forecast messages in twenty minutes or less daily.

Additions to the lists or the cutting out of a name are simple matters, the telegraph company being informed of each change, the proper relay secured, and the town entered on the proper blank accordingly.

FORECASTS ON STREET CARS.

By Mr. N. B. Conger, *Detroit, Mich.*

The method of disseminating weather forecasts to the general public by posting them in a prominent position in street cars has met with great favor wherever it has been practiced, for in this way the forecasts meet the eye of a large number of people.

When the cards are posted in the cars by 11 a. m., they attract the attention of large numbers of people who use the cars thereafter, and thereby the information is disseminated to many of the homes of citizens for their use and benefit in a way that can not be readily accomplished otherwise.

In the city of Rochester, N. Y., the distribution of the cards to the cars is made by the switch tender located at the "four corners" where all the cars pass, and as each car goes by a forecast card is handed to the conductor, who immediately posts it in the proper holder at the front of the car. Thus in a short time all the cars are supplied with forecasts, and the patrons of the road have the full benefit of the forecast early in the day.

In Columbus, Ohio, the practice is to furnish the proper number of the cards to the barns or stations where the conductors hand in their reports, and as each conductor passes in his trip report he takes a forecast card from the packet before him and places it in the holder in the car. Either of these methods is practicable in most large cities. In the small ones the cards can be left at the terminal points in order that each conductor may be served as soon as he arrives.

The effectiveness of the distribution of cold-wave warnings in this manner can not be too highly praised. It enables the Bureau to place before the general public, and more particularly the householder, these valuable warnings as promptly as possible, and it spreads the information widely through the city and is more effective than any warning flag that may be displayed over the office.

This system is simply to be used in addition to the usual method of distributing the forecast cards by mail or messenger. The main point to be kept in view is the bringing of this information prominently to the eye of those who are not so liable to be in places of business where the cards are displayed.

It has been found that where this service has been in operation for some length of time it has become the feature of the service, and has been very favorably commented on by the general public.

The prompt distribution of the forecasts to points where the public can have ready access to them makes them of greater value, and this simple means employed in this direction has been found very effective.

The first distribution of forecasts by street-car service, to my knowledge, was inaugurated in Lansing, Mich., in 1888. The distribution was, however, accomplished by the use of tin symbols carried on the rear of the car, and was prior to the inauguration of the distribution of forecasts by the card system. It is not, however, claimed that it was then an original idea, for it was simply adopting the idea which had been in operation in Ohio for some years of displaying the forecasts by means of symbols on the sides of baggage cars on several of the railroads in that State.

In some cities it is possible that the methods governing the street car systems will not allow the prompt distribution of the forecasts on the cars, so that it would be necessary to station a messenger at a

central point where he could reach the cars as they passed that point. The expense in this connection would be small, probably not equaling the cost of three telegraphic messages daily.

There is in connection with this method of distribution one very important point to be kept constantly in view, and that is, to obtain a rigid rule from the superintendent that the cards shall be promptly changed daily, and that under no circumstances should the card of the previous day be allowed to remain in the holder when the car goes out of the barn in the morning. The necessary regulations are very few, and with hearty cooperation between the street car company and the Weather Bureau official there need be no trouble on this score at any time. The proposition is worthy of attention in all large cities where effective street-car service is maintained.

DISCUSSION.

Mr. L. M. PINDELL (Chattanooga). I consider the display of forecasts in street cars an excellent means of disseminating the information, but the cards must be handled promptly and regularly. When the display was inaugurated on the cars in Chattanooga, I had considerable difficulty in getting the cards on the cars promptly. The officials of the road were eager to cooperate, but through lack of interest on the part of subordinates, the service was slow in being established. Now, however, the cards are displayed regularly and promptly. The letter carrier delivers the cards to the transfer agent, who distributes them to the conductors as the cars come into the station. The car service disseminates the forecasts better and wider in the city and suburbs than the newspapers, because a large number of people do not subscribe to papers. These people see the forecasts as they ride to and from their work. On small cars only one card is displayed, but on long cars one is posted at each end of the car. Not only are the forecasts, but also cold-wave, frost, and emergency warnings, displayed on the street cars.

Mr. J. B. MARBURY (Atlanta, Ga.). Ever since the inauguration of the daily weather forecasts, various methods have been devised for their presentation to the public. Some of these methods have been adopted until superseded by others; while some have been discarded as impracticable. The display of the forecasts on street cars, if it could be generally and successfully inaugurated, would certainly place the benefits within reach of vast numbers who probably would not otherwise see them.

This is not a new question, but one that has been agitated time and again for a number of years past. The fact of its not having become general shows that there must be considerable opposition to the methods so far proposed for their display. So long as it is attempted to use the card and holder now in use I am sure it can never be universally adopted. Their appearance in the car is the objection raised by most car officials, who claim that the cards detract from the looks of the car. Another difficulty is the supplying of the cars with the cards in a prompt manner. I have with me a crude drawing of a device for displaying weather forecasts in street cars, and will try and make it as clear as possible, as well as give my plans for its use. The device is a metallic box or case about 6 inches long 4 inches wide and $1\frac{1}{2}$ inches deep on the inside. At the top is a space 4 inches by 2 inches, on which is painted the words "Weather forecast for ———." Below are three openings extending across the face of the case and

each about half an inch wide. Behind each of these openings is a cylinder, turned by a thumbscrew. On the upper cylinder are the days of the week; on the middle cylinder are the various weather conditions forecast—Rain, showers, rain or snow, fair, etc.—and on the lower cylinder are the temperature conditions—warmer, cooler, colder, cold wave, etc.

These display cases can be made in lots of 500 or more for about 75 cents each. Now, to defray this expense I added a slide at the bottom about 2 inches wide on which to place a display advertisement.

My plan for changing the forecast in each car is to telephone it to the office of the "starter," who would give it to each conductor or place it on his bulletin board. The change would be made by simply turning the thumbscrews at the side of the case. The forecast so displayed is for the ensuing day and would be before the public during the greater portion of the day of issue.

The forecasts may also be displayed in the elevators of office buildings in the same manner.

WEATHER SYMBOLS ON RURAL FREE-DELIVERY WAGONS.

By Mr. L. M. Pindell, *Chattanooga, Tenn.*

In my opinion the Bureau should furnish tin symbols, in conformity with the flags now used, to the rural free-delivery carriers. The latter would, I am sure, gladly attend to the display, and would also distribute the "cards of explanation" to all the patrons along the routes. The routes leaving Chattanooga pass through sections where it is utterly impossible to reach the people by telephone, and heretofore they have been compelled to go from 3 to 8 miles for their mail. They have never had the benefit of the weather service or its reports. With the display of symbols on the wagon as it passes along the county highway the farmer in the field can see what the weather forecast is and arrange his plans accordingly. The symbols in use were purchased at a cost of $4.50 per set. They are 1 foot square, beveled all around to prevent bending, and riveted to an iron rod, each symbol except that representing the cold wave has two tin bands, into which the rod of the other symbol can slide and make the combination. Two iron pieces with holes are attached to the side of the wagon near the top, which hold the symbols. The farmers are very much pleased with the information given them, and insist upon its being continued. I was recently informed by a carrier that the display on the wagon was watched and looked for by the farmers with more interest and eagerness than their mail. We have discovered that the symbols are a little too heavy for the rods; when two are displayed together the rods are liable to break where the rivets pass through. It would be better, I think, if the flags were made out of japanned tin and of smaller dimensions.

CLIMATOLOGY OF FLORIDA WITH REGARD TO CROPS.

By Mr. A. J. Mitchell, *Jacksonville, Fla.*

[Read by title.]

A lengthy monograpn would be necessary to fully discuss the climatology of Florida in its relation to crops. In area Florida embraces 58,680 square miles, mainly between parallels of latitude 25° to 30° north

and longitude 80° to 87° west. The physical features of Florida are pronouncedly dissimilar to those of the other Southern States. The geological upheaval resulting in the formation of Florida bequeathed us neither table-land nor mountain from which to view ocean and gulf. On the contrary, the most elevated portion of the State barely reaches the dignity of a hill. Bathed on one side by the gulf and on the other by the ocean, the climatology of such a peninsula deserves more than passing notice. Already famed as the Riviera of America, holding out hope to the invalid and pleasure and comfort to the robust, Florida occupies a unique place in the Union of States. In one respect she has been the victim of her own good fortune, her commercial importance for a long time being obscured by reason of her reputation as a place of balmy air and friendly temperatures, whose virtues were supposedly paramount in her ability to give sunshine and warmth while other sections were influenced by subpolar conditions. But the investigating mind will ask: "What of her crops? Of these we would like to hear." To more easily comprehend the subject, in the absence of graphic charts, let us divide the State into three divisions, designating that portion north of the twenty-ninth parallel as north Florida, that portion south of 29° and north of 27° as central Florida, and that portion south of 27° as south Florida. Within the areas specified there is grown, to some extent, every staple crop produced by other States of the Union—the cereals of the West and Northwest, the fleecy staple of the South and central West, and the fruits of the Pacific coast—and, in addition thereto, many other products indigenous only to the peculiar soil and friendly climate of a subtropical region. In the study of climate with regard to crop production it would be a serious inadvertence not to consider soil temperatures. Adanson, the French botanist, states that the development of buds is determined by the sum of the daily mean temperatures, counted from the beginning of the year. Another authority concluded that the length of the period of vegetation is in inverse ratio to the mean temperatures; while Sachs, the greatest of plant physiologists, concluded that for each form of plant life there is a minimum, an optimum, and a maximum temperature.

It is obvious, then, even to the superficial thinker, that whenever the conditions are most uniform, by reason of equable temperatures and well-distributed precipitation, a decided advantage results, for the possibility of crop failures is thereby reduced to a minimum. The question of sunshine plays no small part, for actinic energy is an important factor in crop production.

Florida not being subjected to prolonged and severe winters, with great ranges in temperatures, her soil is always in a receptive state, and crop growth is rarely retarded to such an extent as to excite apprehension.

Let us study her crops seriatim.

Cotton.—Sea-island and short-staple are grown with great success some distance from the coast, north of parallel 29 and westward beyond the Apalachicola River. The section where ranges in annual temperature are not marked and where extremely low winter temperatures rarely occur is best suited for the growth of cotton. By reason of our mild winters and the early occurrence of the last killing frost considerable cotton is planted in March, nearly a month in advance of other sections of the cotton belt. The normal precipitation over the Florida cotton belt is about 15 inches for April, May, and June—the period of planting, germination, and chopping. The normal rainfall during

July, August, and September—the period of fruitage—ranges from 16 to 20 inches. Most of our precipitation comes in frequent showers, with intermissions of warm sunshine—ideal conditions for the advancement of cotton. Rainfall is much less during October and November, when the bulk of the crop is harvested. The average temperature during July and August, a critical period with the cotton crop, is practically 80°, while the maximum temperature is rarely 100°.

Cane.—Among other staple products of growing importance we may mention cane. Dr. W. C. Stubbs says that a dry, warm winter, followed by a moderately dry spring, and this, in turn, followed by a hot, wet summer, are favorable to maximum growth of cane. Also, that the mean temperature should range between 65° to 86° (winter and summer means), with an annual rainfall of about 60 inches. In setting forth the most favorable conditions conducive to cane growth, Dr. Stubbs was but stating the real climatic features of Florida. While the State, as a whole, is not given to growing cane, there is an almost endless acreage, beginning about parallel 29° and terminating at the sea, adapted to the industry. The soil is rich in vegetable matter and enjoys an annual precipitation of from 58 to 60 inches, ranging from 6 to 8 inches in the fall and winter—the dry season—to 18 and 20 inches during the summer. The normal sunshine is about 60 per cent. The normal mean temperature for January ranges from 60° to 70° and that for July 80° and above. The possibilities of Florida as a cane-growing State are the more important when we consider that our Government pays $100,000,000 annually to foreign States for sugar. Another fact, which I desire to repeat with emphasis, is that over the greater portion of this possible cane belt frost has never been severe enough to do serious damage, and that throughout the belt the period of the first killing frost of winter, whenever it occurs, is quite a month later than is the case in other cane-growing States—a factor of very great importance, allowing, as it does, a longer period for maturing.

Cassava.—Indigenous to tropical climates, cassava grows perfectly on reasonably fertile, sandy soils, and reaches its greatest perfection where it enjoys immunity from killing frost. The greater portion of Florida is adapted to the growth of cassava, by reason of the eight or nine months of freedom from frosts and the sufficiency of well-distributed rains.

Oranges.—With physical characteristics common to Florida, the success of the citrus industry depends on the range of winter temperatures. With adequate and well-distributed precipitation, and with winter temperatures not lower than 20° over the northern portion of the citrus belt, the orange industry is assured, for with the degree of cold indicated, or even less, its destructive effects are largely mitigated by protective measures. In 1893, with a minimum temperature of 24°, the orange output was 6,000,000 boxes; in 1895, with a minimum temperature of 14° at Jacksonville, the crop was 75,000 boxes. The winter temperatures influencing citrus growth during December, January, and February will be well understood by citing the mean minimum for January, which ranges from 50° to 60°, embracing the extreme northern and southern citrus belts. The lowest temperatures ever recorded over the section indicated range from 18° to 40°. The highest temperatures ever recorded at Weather Bureau stations were less than 100°, mostly 95°. The normal precipitation for January, February, and March ranges from 6 to 9 inches; for April, May, and June, 12 to 15 inches, with an amount a little in excess of this for

July, August, and September, depending largely on the number and near approach of tropical disturbances. The sunshine during winter months is about 60 per cent; during the summer it is about 50 per cent.

Pineapples.—The successful growth of pineapples is markedly dependent upon winter temperatures. Although strictly a tropical plant, it grows with great success unprotected along the parallel of 27°, and northward, under cover, as far as parallel 29°. With protection, pineapples can be grown as far north as Jacksonville. Its native habitat, however, is below the frost line. It is not to be inferred that plants can not withstand moderately cold weather. Light frost does no damage other than retarding growth, for it occurs quite frequently along the east coast, within the pineapple belt. It is only in cases of severe frosts and freezes that the pineapple crop suffers. An annual rainfall of 50 or 60 inches, the bulk falling during the spring and summer, is ample for the pineapple. Heavy dews, in the absence of rain, are of marked benefit. The present methods of protecting plants by means of lattice work was designed, primarily, for winter service, but it is found that the exclusion of intense insolation contributes to the improvement of the fruit; consequently many fields are now shaded during the hot days of June, July, and August. By so doing "scalding" is obviated and the fruit has a better flavor. The pineapple industry is centered in Brevard and Dade counties, along the Indian River and on Lake Worth, thence southward to the Florida Keys. The section enjoys an annual precipitation of 55 to 60 inches, with minimum temperatures rarely reaching the freezing point over the northern portion of the pineapple belt. The varieties of pineapples are the Red Spanish, Golden Queen, Smooth Cayenne, and the Abbaka. The pineapple industry is confined exclusively to Florida.

It will be sufficient to mention the vegetable, melon, and minor crops, in the aggregate amounting to millions of dollars, made possible by their propagation and growth in winter in our low latitudes, and bringing to the agriculturist and horticulturist a reward out of all proportion to intrinsic value. I may here remark that the fruit and vegetable grower of Florida considers the Weather Bureau an indispensable factor in his enterprises, and relies on it for timely warnings of frosts and cold waves with the same degree of confidence that he does the fertilizer which hastens the life and vigor of his plants.

The discussion of agricultural and horticultural interests would be incomplete without stating that the hot waves of the interior are felt with little severity on the lower South Atlantic. The uninformed will ask why this is so. The very conditions contributing to the ultra-equatorial conditions of the continental West bring during the greater portion of the time moderate temperatures incident to the prevailing easterly winds. Being under the influence of the permanent summer high-pressure area of the Atlantic, our agricultural interests are rarely influenced by the extreme heat of the Central West; on the contrary, our winds are of oceanic origin—refreshing to man and vitalizing to the vegetable world. Droughts involving total crop failure are unknown. The cool, rain-bearing winds of the Gulf and ocean give showers over Florida, while the increasing capacity of the air for moisture as it moves inland accentuates a droughty condition over more northerly sections.

SECTION 6.—INSTRUMENTS AND EXPOSURE.

ADDRESS BY CHAIRMAN, PROF. CHARLES F. MARVIN.

We are all here together for the general good of the service. This, I take it, is the primary object of the convention, and there are a great many things I would like to say to you, but you all see that time is very short, and I am satisfied this convention is peculiarly the opportunity of the station officials. This is their inning and we of the central office want to hear everything they have to say, so I am going to take but a minute of the little time that now remains to say a few words on my subject.

I am very glad Professor Moore said what he did yesterday about independent observatory buildings in parks or elsewhere. I knew the subject had been under consideration, and I am glad it is up for all of us to think about.

In inaugurating this great advance in our work I am afraid we will be, if possible, too modest in our ideas. No observatory should be put up now, or a few years hence, that is not the most perfect thing of the kind. The whole thing must be planned and worked out now on a line and in such a manner that the institution will answer all the purposes that will be expected of it ten or twenty years hence, and we must leave room for enlargement and expansion in directions we do not think of now.

In my opinion a small city lot will not do. We want an acre or two of ground at the least. Of course, in many cities, all the ground we need can be had gratis in all probability, but we must not skimp ourselves elsewhere when we have to purchase. Our present exposures are, alas, far from perfect in many instances, and the problem perplexes my division very much. I believe the only solution is the independent institution.

It goes without saying that the accuracy of the Weather Bureau records must be maintained beyond criticism at any price.

There is much more on these points to be said, but I will close with a word or two on instruments.

We are trying to give every station of consequence a full and standard equipment. Few of you realize, probably, how difficult this is with the funds available, but we hope all of you will be pretty well satisfied by the end of one or two more years.

A great many of you want tele-thermographs, which are not at present among the instruments regularly supplied. These registers are made abroad, and in their present form are not exactly suited to our needs. We are working on the problem ourselves, however, and I think a fine telethermograph will be one of the regular instruments at all important stations a few years hence. I can only ask you to be a little patient in the meantime.

We are about to make a radical change in the mounting of the maximum thermometer. In spite of our most rigid inspection and testing at the Central Office occasionally the mercurial column in some maximum thermometers "retreats" after the maximum temperature has been passed and an erroneous record follows.

All these errors are obviated by mounting the maximum with the bulb end higher than the top. This unfortunately necessitates lowering the thermometer to a vertical position when the reading is made. I will not attempt to discuss the merits of this departure at this time,

but merely mention the matter for information. I obtained a proof of a new illustration showing this mounting just as I was leaving Washington, and pass it around for you to see.

DEVICE FOR AUTOMATICALLY RECORDING BEGINNING AND ENDING OF LIGHT PRECIPITATION.

By Mr. O. L. Fassig, Ph. D., *Baltimore, Md.*

For many years a simple and effective device has been in use at Weather Bureau stations for indicating the occurrence of light precipitation, namely, a sheet of paper containing lines in copying ink exposed to the open air to catch the few drops of a shower, often too light to leave even a measurable trace in the rain gauge. The blurred lines upon the sheet where the rain has touched the soluble ink, while indicating the occurrence of rainfall, gives no clue as to the time of fall.

It occurred to the writer recently that the usefulness of this device might be extended by putting the paper in motion under cover excepting a small aperture for allowing the rain drops free access. To accomplish this purpose, an extra anemometer register which happened to be available was employed. The time lines and printed instructions upon the face of the wind-velocity sheets being in copying ink, served the purpose excellently. After placing the sheet upon the revolving drum a cover was placed over the latter, leaving only a small circular opening at the top about a quarter of an inch in diameter. The aperture was afterwards enlarged so as to extend entirely across the sheet of paper, still leaving the width about a quarter of an inch, while the number of lines upon the sheet was increased. The other parts of the register were, of course, also covered in order to avoid injury from rain.

This method may be employed with advantage at stations not supplied with the rather expensive self-registering rain gages in use at the more important Weather Bureau stations. By its use the frequent entries upon Form 1001 of the vague and unsatisfactory terms "rain began and ended during the night" may be entirely avoided. By increasing the rate of movement of the record sheet any desired degree of accuracy in noting the time of beginning and ending of precipitation may be attained. An equally satisfactory result is obtainable by means of the tipping bucket register only in case of an abrupt beginning and ending of a smart shower, as no record at all is made until one-hundredth of an inch has fallen. The record not only marks the actual time of the rainfall; it shows also the character of the fall, scattered drops indicating a light intermittent fall, a continuous blur indicating a heavy shower. The expense of the registering device is small, permitting its use at a large number of stations.

The method has been tested at the Baltimore station during the past few months under many different conditions, varying from a light sprinkle to a heavy shower, and at times of heavy continuous downpour. The results have been quite satisfactory, even with the crude improvised register described above. An instrument designed especially for the purpose would yield much more satisfactory results, and might profitably be placed in the hands of our voluntary observers, thus greatly increasing the value of the rainfall record.

The character of the records obtained is shown in the accompany-

ing original record sheets.[a] Some of the imperfections noticed, such as the splashing and running of drops during a heavy shower, may be avoided by moving the sheets horizontally instead of placing them upon a revolving drum. The lines should be fine and closely drawn.

The method here described is of course of little value when used alone; taken in connection with a quantitative measurement, however, it affords valuable supplementary information.

DISCUSSION.

The CHAIRMAN. In regard to this paper I would like to say that while the idea is elegantly worked out and applied by Dr. Fassig, it has been frequently proposed at the central office, but thus far has never been tried. The subject will be further discussed by Mr. Oberholzer, who has also done some work in this connection.

Mr. OBERHOLZER. I have thought of this matter of indicating the beginning and ending of light rains for some time, and the idea of Dr. Fassig had suggested itself. I met the objection, however, of the rain spreading so much. I have thought of, but not completed, an electrical device by which drops of rain will be caught between bars of steel, completing a circuit and registering on a cylinder that revolves rapidly. I believe that can be practically worked out, but I have not completed it. I would like to talk about the importance of a registering rain gauge at every station. I believe that the rate of rainfall is almost as important as the amount. Frequently requests come to us at stations for the maximum rate of rainfall from people who wish to construct spouting, engineers who wish to construct culverts, etc. They wish to know how much water they should be prepared to carry off in a given time. If we do not have good automatic records, we can not furnish the necessary information. There should be some sort of table of rainfall, similar to the table on the back of the triple-register form. I have had some difficulty in getting the tipping bucket to register accurately every hundredth of an inch of rainfall, owing to dust in the city atmosphere. I have completed a circuit between the tipping bucket and the frame. I find that there is a good deal of difficulty in a smoky atmosphere from dust getting into the bearings of the tipping bucket and soiling them. In addition, oxide will quite readily form on the horizontal surfaces that form at the points at which the tipping bucket is supported, thus breaking circuit whenever the bucket tips. By putting an extension to the axle of the tipping bucket and fastening to it a coil of fine wire, which is further fastened to the frame, I find that we get successful records, even with oxidized contacts. Further, I believe the tipping-bucket gage should have adjustments by which the number of tips to the inch could be regulated. I find that in summer time, when showers come suddenly and heavily, there should be more tips. To correct the errors in heavy rainfall I screw out my adjustment, causing the gage to make more tips than otherwise. Such errors as may creep in, due to the corrosion of the bucket with age and the accumulation of dirt, would also be corrected by this adjustment. I found it quite successful on the gage I used for several years. I have thus been able to get accurate rainfall records when I know I got practically every hundredth of an inch that fell—within 2 or 3, or at most 5, per cent.

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[a] These record sheets have been reproduced and accompany this paper as Pl. XXXVII, figs. 6 and 7.

Plate XXXVII. Specimen Records of Beginning and Ending of Light Precipitation.

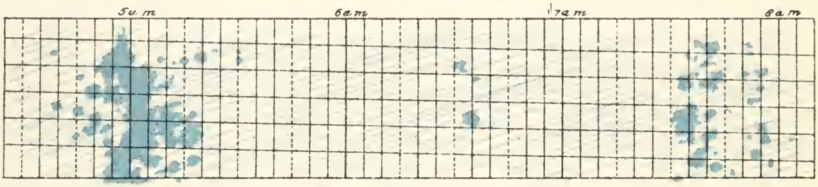

Figure 6. Very light shower.

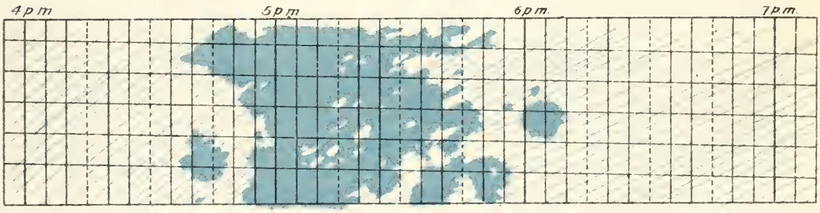

Figure 7. Light shower.

SUBURBAN METEOROLOGICAL OBSERVATORIES.

By Mr. A. F. SIMS, *Albany, N. Y.*

Professor Abbe has said:

In these days, governments and private individuals vie with each other in stimulating physical, chemical, and astronomical science, and in the great universities laboratories and observatories have been equipped with the finest apparatus and provided with the most learned mathematicians and the most skillful experimenters, and it is well recognized that great advance is best made by men who to inherited gifts have added the great advantages of study and training. Meteorology has, to date, received but meager recognition, notwithstanding the fact that it is of great importance to mankind and is a science of highest utility.

Such a train of thought suggests that suitable buildings be erected in city parks as a method for carrying out the system of suburban meteorological observatories that it has for a long time been the desire of the Chief of the Weather Bureau to establish. In such schools of investigation, in line with philosophic methods and instruction, young men, after proper preparation, could perfect themselves in the study of meteorology; parents and school children learn something of nature's secrets, and professional men bring our science into use in their daily work. There, also, Weather Bureau officials, temporarily relieved from the large amount of executive work devolving upon them, could give time to experimental work and investigation in the higher and broader fields of scientific investigation for which they are qualified.

Model meteorological observatories should be constructed to enable us to get the proper exposure for our instruments, install a library where anyone who would engage in any line of scientific work, and especially of original research, could get a knowledge of correct principles and the best methods, and also of what has been already done.

For this special meteorological library, incontrovertible facts could be collected by a board of experts, and, as future research brings new facts to light, they could be filed for use in connection with the solution of complicated problems presented. A set of meteorological works and hand books of reference could be compiled that would treat of the elements in a popular tone, that would meet scientific demands for accuracy, and be clear and comprehensible to the ordinary understanding, and make teaching sound and thorough.

Within the walls of such meteorological laboratory, extensive pieces of research could be planned and promising investigations carried on. In such an observatory, meteorological theories, built up as facts accumulate, could receive further demonstration by experimental research or otherwise, and nature's processes reproduced, and effort made to learn more of her mysteries.

It is our especial privilege to aid in the sublime work of placing meteorology among the exact sciences. At present we are greatly hampered and trammeled and fail to fully understand meteorological phenomena, for the reason that we must base our knowledge of air flow and its physical condition on observations made on roof tops in the begrimed air of the populous portion of the city. Suburban observatory instrumental exposure offers a means whereby we can get rid of one of the most serious obstacles to exact observation, namely, diversity of exposure of standard instruments of precision.

The accurate measure of precipitation is of importance to meteor-

ology and engineering; correct rainfall measurements could be secured in the experimental rain field in the observatory grounds.

In an experimental thermometer plot, thermometers could be exposed at various altitudes and data secured for use in connection with research into the history, effect, and method of protection from frost and application to the growing of plants in the most favorable locations. Within such plot we can collect data which, when properly correlated, will be valuable in connection with the study of temperature distribution in soil, and in the study of animal and vegetable life.

The present exposures and outdoor facilities of the Weather Bureau station at Albany, for all instruments, are decidedly unsatisfactory; the same condition obtains in other large cities. The progressive manufacturer constructs his buildings and arranges his factory to best suit the needs of his enterprise, places the best tools and appliances in the hands of intelligent men, and a superior product is the result. The same method of procedure applies equally well to our institution. The best is none too good for the work we have in hand.

In a number of suburban observatories, designated as schools of application, normal methods, in the meteorological training of our young observers, could be instituted, and thus, in course of time, would the young mind become the repository of many thoughts and be filled with desirable images. Such minds would connect, without confusion, the past with the present and penetrate into the future.

IS EXPOSURE AT WEATHER BUREAU STATIONS SATISFACTORY FOR ALL INSTRUMENTS?

By Mr. T. S. Outram, *Minneapolis, Minn.*

All the instruments at Weather Bureau offices have their particular uses which could not be dispensed with by either the official or the lay forecaster. The records of some of these instruments might be said to have a commercial as well as a scientific value for the reason that they are much used in our everyday business life; therefore, to secure a proper exposure for all these instruments is an important matter. To obtain a good exposure for the wind instruments, barometers, etc., is generally a simple thing, but to secure a site for thermometers and rain gage where accurate readings are possible is very difficult, if not entirely impossible under the conditions governing the placing of instruments at our regular Weather Bureau stations. There is this to be said, however, and that is that the exposures are all very much the same, the whole country over, and that they are therefore comparable one with another.

The subject of the exposure of rain gages has been fully discussed by Prof. Cleveland Abbe, in a paper entitled "Determination of the true amount of precipitation and its bearing on theories of forest influences." In this paper Professor Abbe gives details of a varied series of experiments with rain gages under many different conditions, made by Prof. Joseph Henry of the Smithsonian Institute. Professor Henry finally concluded that the best exposure for a rain gage was in a pit so arranged that the mouth of the gage was not much above the level of the ground, thereby eliminating air currents and eddies which at greater elevations materially lessened the amount of rainfall caught by the gage. Of course the use of such a "pit gage," as he called this one, is out of the question at regular Weather Bureau stations, but could not the pit idea be carried out by having the gages suspended through a hole in the platform where they are

usually exposed and in this way cutting off the disturbing air currents about the mouth of the gage? I think that the splashing into the funnel from the platform and the rising of air currents alongside the funnel from below the platform could be prevented in a simple way.

The time is past when our temperature readings are not regarded as thoroughly reliable, but it is a very common thing to hear it said that the "Government instruments are very conservative." It is frequently said that temperature records should be kept "where we live" and not away up there in the air, but the securing of true conditions on the street would be impossible where there are so many reflecting and radiating surfaces, and if such a record were made it would not seem correct for every individual, for there is in every person an ability to resist heat or cold which varies with his continually changing physical condition. There is then only one correct way to record temperatures and that is by placing our instruments in free air, sheltered from reflection and radiation, and this the Weather Bureau does within its limitations, but at most stations entire freedom from these influences is almost impossible. How much our moderate-temperature readings depart from the true temperatures I can not say, but I am convinced that our winter readings are too high, because the thermometer must be surrounded a good part of the time by a column of heated air rising from the hot buildings on which our shelters are placed. The greatest difference between the true temperature and that recorded will be when the wind is so light that the ascending heated column is not disturbed, and that is usually when the temperature is the lowest. While on the subject of temperature readings it might be well to suggest the slight coloring of the spirit in minimum thermometers intended for the use of voluntary observers; it would tend to prevent many incorrect readings.

THE MAXIMUM AND MINIMUM THERMOMETERS ARE TOO FRAGILE. CAN NOT EFFECTIVE PROTECTION BE DEVISED WITHOUT IMPAIRING SENSITIVENESS? SHOULD NOT ALUMINUM SCALES BE DISCARDED?

By Mr. G. R. Oberholzer, *Charlotte, N. C.*

Thermometers are, necessarily, delicate instruments. A material less fragile than glass that could be substituted for it in the construction of thermometers is not known now. Improvement looking toward rendering this instrument less liable to injury will naturally be confined to the method of mounting the glass stem and to the mount or back itself.

It would be difficult to devise protection for the thin glass bulb without, in some measure, impairing the ventilation, and, consequently, the sensitiveness of the instrument. The back now in use offers little protection against breakage of the stem, yet the free flow of air is, to some extent, impeded. It is questionable whether a thermometer should register, as the maximum of the day, the temperature of a puff of air that has been superheated by some roof top, or by the side of a building that seems to undulate in the glare of the afternoon sun. A sensitive thermometer will do this. It is believed that the Weather Bureau thermometer can be mounted so as to have necessary protection and lose nothing of its value as a meteorological instrument.

All the more recent thermometers are mounted on a strip of aluminum about six one-hundredths of an inch thick, and less than an inch wide. They are securely held in a groove, that has been stamped into

the metal, by two clips, practically making the brittle glass a portion of the back itself. A slight bend of the soft metal will snap the stem; a blow on the back will be transmitted, with full intensity, to the glass; no shield is provided against violent contact with the glass from the front. A jar received by the bottom of the instrument tends to break the projection from the top of the glass stem, allowing it to slip down, breaking the bulb. A turn too much of the screws that fasten the stem to the mount will prove disastrous. Indeed, with the present mount, all blows or bends received by the back will be transmitted, with little diminution of intensity, to the fragile glass itself, and the back offers little protection from direct blows.

To remedy these defects in a measure a back was devised that I beg to offer for your inspection. Since it is the first design made, it is, of course, capable of much improvement. The back is of a semitubular form, which makes it at once light and strong, and also offers as ample protection to the tube as is consistent with reasonable ventilation. A blow received on the edge of this back will not be transmitted directly to the glass, but will be distributed by the elasticity of the mount. The glass tube is suspended from a brass spring fastened to its top, which tends to break the force of a blow on the top or bottom of the instrument. Brass springs are also introduced under the glass stem to break a jar from the back, and to give it an elastic fastening, making it proof against bends or twists. By this method of mounting the glass, blows that would ordinarily shatter it are received on a surface that will yield sufficiently to materially break the force of contact.

Aluminum, commended by its lightness, has been put to a great variety of uses, particularly in instrument making, shipbuilding, and for electrical purposes. It has not met with marked success in any of these directions. Electric furnaces that have been used in the recovery of the metal are being used to some extent in making calcium carbide, indicating that the use of the metal is not growing. The Navy Department some time since refused a consignment of megaphones because the mouthpieces were made of aluminum. The director of the British Aluminum Company says that in no case should this metal be exposed to the action of sea air or water without a protecting coat of paint or varnish. As a thermometer back we know how readily it corrodes, especially when near the coast. It most frequently forms a chloride, which is the familiar gray covering on our thermometers, rendering the scale practically useless, as well as unsightly. I have scraped these thermometers; used sand and emery paper; polished them with crocus and rottenstone; I have covered them with varnish and lacquer, all to little purpose. The objection to this remedy is that it will not stop the corroding, and the substitution of new thermometers will have the further disadvantage of breaking a quartet of instruments that are in accord, which is done with reluctance, however old the instruments.

The addition of copper to aluminum will make an alloy that is slightly heavier than the latter metal, but so much strength and durability results that it is used extensively in the arts. Recent experiments by the German admiralty indicate that aluminum bronze is not attacked by sea air or water if kept in contact with a metal that is electro-negative to it. Sir William White, of the English navy, has come to the same conclusion. It seems that it would be well worth while to try mounting aluminum-bronze thermometers on metal supports having this property.

The thermometer shown here has a back of enameled steel, which was courteously shaped and enameled by the National Stamping and

Enameling Company, of Baltimore. This back is at once durable and easily cleaned—indeed, it is nothing more or less than strengthened porcelain. It was found that any desired lettering could be fused into the glaze of this enamel, making it part of the back itself.

DISCUSSION.

Mr. P. F. Lyons (St. Paul, Minn.). In opening this discussion I shall simply confine my statements to what has been learned during my practical experience with the instruments in question at the regular stations of the national weather service for more than a quarter of a century, during all of which time neither breakage or even serious injury to any of those instruments has happened through either my manipulation or that of any of the observers at the stations where I have been on duty. Hence to the assumption, "The maximum and minimum thermomters are too fragile," etc., I must give a negative reply. They are not too fragile; but, perhaps, in selecting this topic for discussion, instruments suitable for sub-stations or volunteer stations, as well as for regular ones, were in view. As to the needs of sub-stations and volunteer stations, I acknowledge to having but a limited acquaintance compared with that of many of you who undoubtedly have had years of experience with them, and consequently you are better qualified to decide as to the pattern or kind of instrument best suited to them.

If the aluminum scales to thermometers were introduced with the expectation that the metal was not susceptable to discoloration, corrosion, or rust, etc., the same as brass and other base metals, the expectation has not been fully realized. In my experience, I have found that aluminum will not tarnish or blacken nearly so soon as brass, etc., but it will corrode after exposure for two or more years in cities where the usual soot, smoke, and other air impurities are abundant, and this deterioration is such that it can not be removed without the use of emery, and only then with some difficulty, whereas the other scales can be cleaned much more easily. If the object sought by the introduction of aluminum was a scale superior to the porcelain, I don't see that it has been attained.

The Chairman. Aluminum was adopted as advantageous because it goes easily through the mails. The postal regulations exclude matter weighing more than 4 pounds, and we often ship a batch of thermometers to stations that can be barely passed under the 4-pound limit. The express companies, I am sorry to say, break our delicate instruments relentlessly. There has been some improvement of late years, but we like a thermometer as light as possible, so we can forward it through the Railway Mail. That is one advantage aluminum possesses. Mr. Oberholzer pointed out the objection I made to his mounting. In order to expedite the work at the Central Office, and compare thermometers without defacing or soiling the backs, it is necessary to detach the glass, and we desire a mounting that facilitates this as much as possible, as, where we have 400 or 500 thermometers, taking off and putting back the glass tubes is quite troublesome.

SHOULD NOT THERMOGRAPHS BE FURNISHED TO VOLUNTARY OBSERVERS, THE RECORDS TO BE KEPT AT SECTION CENTERS?

By Mr. A. B. Wollaber, *Portland, Oreg.*

In answer to this question, I would say that the furnishing of thermographs to voluntary observers and the compiling of the records thus obtained at the section center would, without doubt, prove a valuable

addition to our rapidly growing fund of climatic information, besides affording an excellent check on doubtful temperatures as recorded by observers using maximum and minimum thermometers at voluntary stations.

The addition of a thermograph to the equipment of a voluntary station would also tide over breaks in the records caused by the observer's temporary absences, and an incomplete record, as every one knows, seriously impairs its usefulness. The annual means are of the greatest importance from a climatic standpoint, and they are only too frequently incomplete from this cause, and inquiries regarding the annual temperature for many districts remain unanswered, notwithstanding a station is maintained in that neighborhood.

In States where the regular Weather Bureau stations are wide apart, hourly temperature records at a few well-selected stations along the lines of railroads would add greatly to the usefulness of the records. It frequently happens that a Weather Bureau official is required to furnish to transportation companies temperature data covering the transit of perishable goods from one end of a State to the other, and, in such cases, hourly temperature readings would be of much practicable benefit. In a mountainous country, where freezing temperatures are an almost nightly occurrence, the records obtained by the use of thermographs might be of value to our forecast officials in the study of air drainage, frost, and cold-wave conditions, and any addition to our knowledge regarding these phenomena would prove of direct benefit to agriculture in general, and particularly to the horticulturist and market gardener in the spring and fall, and to the stockmen in winter.

It is not thought, however, that it would be advisable to furnish such delicate instruments to all voluntary stations, as many voluntary observers already have all they care to do in taking the daily eye readings required. In all States there are to be found observers especially interested in collecting meteorological data and who take great pride in their work, and these are the men who should be supplied with thermographs. It is also believed, in this connection, that a limited number of storm-warning display stations should be supplied with barometers or barographs, and with anemometers for recording the wind velocity. During the display of storm warnings vessels are frequently held in port, and on such occasions their masters are in close communication with storm-warning displaymen, and they quite frequently desire to compare their barometers and obtain information regarding the force and direction of the wind.

THE INTRODUCTION OF AUTOMATICALLY RECORDING RIVER GAGES.

By Mr. WESTON M. FULTON, *Knoxville, Tenn.*

Not more than a century ago our rivers and their tributaries flowed for the most part through forests, broken only here and there by cleared patches which had been made by early settlers. The close of the century finds vast expanses of fertile and well-tilled fields where these forests once stood. These fields form a large portion of the agricultural lands of the United States. In fertility of soil they excel the uplands, and are sought by the agriculturist. Also many small towns and villages and a number of populous cities now stud the banks of our more important waterways. Early methods of transportation

rendered these cities of great importance as commercial centers, and they have generally outstripped in wealth and population other cities which were not so located.

Without further remark it will be apparent to every thoughtful mind that the incentive for the study of river stages is to-day vastly greater than it was a century ago. The value of accurate water-stage records is increasing year by year, and the question which I now wish to advance for discussion is, Has the time not already arrived when automatic recorders should begin to replace the divided scale? If in 1873 our Government was justified in establishing a river and flood service, is it not now justified in increasing the accuracy and copiousness of the water-stage records by locating automatic-recording gages at the more important stations at least?

I take the affirmative side of this question for the following reasons:

1. Public interests justify this action.

2. The cost of erecting and maintaining automatic gages is not greatly in excess of that of the present gage.

3. Automatic records are of much greater value in making river forecasts, as well as in informing the public of water fluctuations, than are the once-daily eye readings.

(1) The late official census tells us that about 30,000,000 of people dwell in the Mississippi basin alone. The region which is drained by the Mississippi river and its tributaries embraces about 2,240,050 square miles, or 41 per cent of the total area of the United States, exclusive of Alaska and recently acquired territory. A sudden and decided rise of water in one of our important waterways, if unheralded and hence unexpected by dwellers in the lowlands, may result in loss to movable property exceeding in amount the annual cost to the Government for maintaining the entire river and flood service of the United States. These facts, together with many others already familiar to the general reader, will leave no doubt that public interests justify a careful study of water stages in rivers, based upon accurate automatic records.

(2) In the year 1897 I designed an automatic recording river gage which was intended to be constructed and installed in the Mississippi river at Vicksburg, Miss. About this time, however, official duties called me to Knoxville, Tenn., and the idea was temporarily abandoned. But the gaging of the Tennessee river at Knoxville, which came within the scope of my work here, soon revived the problem of constructing an automatic recording gage, and the plan was suggested to Mr. Allen Wade, who was a student in the engineering department of the University of Tennessee, and who was also my assistant. Mr. Wade evinced much interest in the idea, and in the spring of 1899 he and I undertook the work of constructing an electric recording river gage. The gage which was the ultimate outcome of these efforts has been described at length in the Engineering Record (New York), volume 41, pages 221–222, and in the University of Tennessee Record for October, 1899. It was installed in the Tennessee river at Knoxville on January 9, 1900, and records were continued until the ensuing summer. They were then temporarily discontinued for the purpose of remodeling the gage.

In the light of the experience gained from these experiments, it is believed that automatic gages of a similar pattern could be constructed and erected at an average cost of $100 each. Of course, in the larger cities, where the distance of the Weather Bureau office from the river and the closely built up city streets would render the cost of wiring excessive, the gage could be made direct recording.

From these considerations it will be seen that the cost does not prohibit the adoption of automatic gages.

(3) The records obtained from the gage referred to above indicate that the once-daily eye readings of water stages in the Tennessee River, which have been made at Knoxville during the past thirty years, seldom, if ever, indicate the exact time at which any flood wave arrived at this point, or the rate at which the water changed in height during the passage of the wave, or the maximum height reached. The highest and lowest monthly and annual records are, perhaps in many cases, in error by several feet. While this, perhaps, can not be said of the daily scale readings at stations in the lower rivers, where fluctuations in water level are less decided and less sudden than in the upper tributaries, it must not be forgotten that it is in the upper tributaries that floods originate, and for this reason, if for no other, automatic records there are of greatest importance.

With his knowledge of the value of the barograph records over the eye readings of the barometer, or of the thermograph records over the readings of the thermometer, no experienced observer can question the value of automatic river records over the eye readings.

RIVER GAGES IN THE UPPER MISSISSIPPI VALLEY.

By Mr. W. W. Carlisle, *Minneapolis, Minn.*

[Read by title.]

Not many years ago a long coast line and extensive navigable river systems were considered the greatest requirements for the prosperity of a commercial nation. Times and conditions have rapidly changed. The Father of Waters enters but lightly into the problem of commercial aggression. In the matter of domestic trade before railroads were born, river highways were invaluable and the plodding steamboat indispensable. Cities situated like St. Paul could not have existed without them, nor would there have been any excuse for their existence. The river trade on the upper river was then an ever-increasing success, and the steamers plying between St. Paul and St. Louis were numbered by the hundreds, but from the time of the arrival in St. Paul of the first railroad train the river business began to shrink. Boat after boat was taken out of the trade, until to-day, and in fact for twenty years past, a single line of steamers leaving St. Paul once or twice a week is all that remains of the upper river transportation. On the Chippewa, where formerly many light-draft steamers did a prosperous business, not a single steamer remains. There are other streams which the Government has faithfully and at great expense kept in a navigable condition which have the same history and the same pessimistic outlook.

Transportation on the upper Mississippi and on the smaller navigable streams does not appear to be profitable. The channels are too crooked and too shallow to allow successful competition with the railroads.

If, then, the introduction of an expensive system of automatic river gages is to be made merely and solely for the benefit of the river trade, basing an opinion upon the foregoing remarks, the upper river business does not seem to warrant the outlay. Yet there are, besides the steamboat interests, other claims to consider. For instance, as a mighty and, to a certain extent, self-purifying sewer for the cities

along its banks the Mississippi is invaluable. It is just possible that at some future time it may become very necessary to possess accurate data of the water volume in order to know how much sewage per mile can safely be emptied into the river. The present system of gages seems hardly sufficient for furnishing records that could satisfactorily be used for such a purpose.

Then there is the utilization of the enormous energy of the rivers. Engineers must have certain facts upon which to base their plans, and are even now asking us for them. Above St. Paul, and in the smaller tributaries, we have nothing at all to offer them. As a sequence to natural economy, the time must certainly come when all possible water power will be used, and the Weather Bureau should be ready to furnish the engineers with all possible facts pertaining to river flow.

In the Chippewa river, already mentioned as profitless as a means of transportation, there are several points where apparently power enough might be developed for large manufacturing plants. Yet if an engineer were to request us to furnish him with a twenty years' record of the constantly fluctuating channel depth of that river in order that he might discover the actual average energy of the stream, or that he might construct an enduring dam at the least cost, or plan for the installment of the exact amount and kind of electric equipment we would simply have to turn him away with no information at all, for we have no gages in such rivers. These engineers have been compelled to base their calculations upon mere legend, and some costly mistakes have already been made.

In the Mississippi, below the St. Anthony Falls, a dam has been constructed, which, with a normal supply of water, furnishes power for the street-railway systems of both Minneapolis and St. Paul. It was only by costly experience that this company learned that sudden cold weather would arrest the flow of water; that on some cold-wave nights its power would suffer a shrinkage of something like a thousand horsepower, which, of course, had to be made up by steam. When we have sufficient data to enable us to successfully forecast the shrinkage of power which this and other water-power plants yet to be built will suffer during the passage of a cold wave, we will have added another valuable function to our Bureau. There are many things concerning river flowage we ought to know. For instance, all the available power of the St. Anthony Falls is used in the flour mills, and in low water auxiliary steam power has to be used. This low stage is hastened and considerably aggravated by the loss of the millions of gallons of water daily pumped into the city mains. We should have the facts in our possession, and we should be able to inform the city engineering department to what extent they must increase the headwater reservoir system in order to maintain the proper stage at this point. It would also be interesting to know how much water sinks into the earth through the bed of the river, and what effect vast headwater reservoirs may have upon the artesian-well flow.

In time a complete system of automatic gages will put us into possession of many facts that are now unknown. The proper gage to use must not only be automatic, but it must work in ice as well as in the open season. We want the full annual record of all streams that have a significant flow.

It is comparatively easy to construct a three-wire instrument recording feet and tenths, but the real difficulty lies in making the instrument work independently of waves and ice. It seems to me that this difficulty may be overcome as follows: Design the instrument to be

worked by a heavy floater of, say 90 per cent specific gravity with counterweight. Inclose these weights in well tubing, and to the tube which contains the floater attach an ordinary strainer point such as is used in driven wells. Drive the tube into the river bed until the strainer is something like a foot under the sand. The water will then rise through the sand until it stands in the tube level with the outside surface. The water in the tube will now follow the rise and fall of the river, being perhaps half a minute behind. The level of the water in the tube being determined by the average pressure upon the river bed, the effect of the wave element will be nil. Such an instrument would be useful also in recording the mean rise and fall of the tides. To prevent the freezing of the floater we have only to pour down the tube a sufficient quantity of a non-freezing oil to depress the water surface below the depth to which ice forms.

SECTION 7.—AS OTHERS SEE US.

The CHAIRMAN (Professor Moore). The session this morning is for the purpose of closing up some details and hearing remarks from friends that are with us. I would especially like to hear from one of our guests, who is well known as one of the greatest statisticians of the country, and who was once in charge of the statistical work of the Department. I would like to hear a word from Mr. B. W. Snow, of Chicago, Ill.

Mr. SNOW. I had not intended to make any remarks, yet at the same time it is a pleasure to be present with gentlemen whose work I follow as closely as I do the work of the Weather Bureau. As some of you know, I pay special attention to the condition, the prospects, and the final results of the principal crops of the country, making that my sole business. I would not do justice to myself if I did not take occasion at this time to say that in this work I receive more help—more that is useful, in fact indispensable, in my work—from the weekly reports of the climate and crop service of the Weather Bureau than from all other sources combined. [Applause.] I conduct practically a service of my own, having a representative (and sometimes several representatives) in all counties between the Alleghenies and the Rockies; but a man who understands crop growth and the conditions which govern crop growth, if he be thoroughly intelligent, could take the weekly reports made by you gentlemen, and without another scintilla of data could frame an accurate judgment of what the crops would be. [Applause.]

The chair introduced Mr. Charles B. Murray, of Cincinnati, Ohio.

Mr. MURRAY. When I was coming here I felt glad of the opportunity to say something regarding the early history of the Weather Bureau, but inasmuch as that has passed beyond your interest I presume it is not now in order. But I want to say at the outset that the Weather Bureau service, as it took form in its application to the public interests, began in the Cincinnati Chamber of Commerce, and began with Professor Abbe. And I desire to express to Professor Abbe, through you, our appreciation of the valuable service he rendered to the country at large in the initial work that he performed there at Cincinnati. [Applause.] If you will allow me, I will suggest that I regard the Weather Bureau work as neither an invention nor a discovery. It was simply the creation of an incident, and that incident came about with operations

of the Western Union Telegraph Company.[a] The Western Union Telegraph Company, in the prosecution of its work, had to receive such information as you are now receiving in regard to weather conditions, temperature, etc., to enable it to regulate the working of its wires. This was about 1868. The Western Union having inaugurated the collection of such information as would be useful at that office, Professor Abbe had the wit, the knowledge, and the discernment to see that there were elements which could be utilized in getting together information by which forecasts could be made. The prior object was not one of forecasts, but simply of records or announcements of weather conditions. The Western Union took up the work and inaugurated the issuing of a series of charts, with which, I presume, you are familiar. I have with me a copy of one of the old ones, of about 1869. The Western Union Company ultimately disposed of that, and the Cincinnati Chamber of Commerce, at its own expense, for a period inaugurated the whole work incident to the Weather Bureau endeavor. It secured the cooperation of Professor Abbe, and as a part of that work he went to Chicago to confer with the Chicago Board of Trade and get their cooperation. But the Chicago Board of Trade did not think there was enough of public interest and commercial interest to justify their going into it, and they turned the proposition down. But the Cincinnati Chamber of Commerce stayed with it. Professor Abbe's work was appreciated, and about 1869 the work was well inaugurated. By the early part of 1871 it had become so thoroughly established that the Associated Press asked the Signal Office the privilege of receiving in the morning—say, about half past 1 o'clock—these reports for transmission for the general information.

These were some of the items of the beginning of this work, and I could follow them up much further, but it is not necessary. I want to say, however, that while we have no basis of comparison of the value of one branch of the public service with another, we may readily accord to the Weather Bureau to-day the credit that, perhaps outside of the statistical work of the Treasury Department, there is no other service rendered by a Government bureau that, in my judgment, has a higher claim upon the consideration of the country.

Professor MOORE. We are more than pleased to have Mr. Murray with us. He is the editor of the Cincinnati Price-Current. We are glad to have him call attention to the primary work done at Cincinnati in the organization of this service. Milwaukee and Cincinnati can shake hands over that question. Professor Abbe in Cincinnati, with the aid of the Cincinnati Chamber of Commerce, and Dr. Lapham, in Milwaukee, with the agitation he carried on for years, were the two spirits that moved this Government to take the action that finally resulted in the convention we are holding to-day.

Now, before introducing Mr. LaVerne W. Noyes, of Chicago, permit me to say a word about him. He is the president of the Civic Federation of Chicago. He has some right to be with us because he manufactures windmills, though he does not like to have them called

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[a] According to Professor Abbe, the collection of reports by telegraph began with the Smithsonian Institution about 1852, and its daily weather chart began shortly after. In May, 1868, he proposed a similar but more elaborate work to the Cincinnati Chamber of Commerce, which was carried on until January, 1870, by himself as director of the Cincinnati Observatory. From that time until May, 1870, he utilized the less expensive reports of wind and weather sent in by the telegraph operators. From May until November, 1870, the bulletins and charts were kept up by the officials of the Western Union Company.—[Editors.]

windmills—they are aermotors. He has made so many inventions himself, to improve the efficiency of the aermotor and get the greatest power out of a given wind velocity, that he has made his name famous all over the country as an inventor.

Mr. LAVERNE W. NOYES. Probably the daily work of no other body of men in the world is so closely scanned by so great a number of people of high average intelligence as the work of the United States Weather Bureau. That the work meets with such general approbation should be a source of great gratification to the workers.

It is not always a pleasing task to tell a person frankly how others see him, but in my case there is nothing to withhold. Most people look at your work from a single point of view, to wit, to know whether to set sail or to know how many hours yet remain to get the hay in stack or under shelter; to determine what kind of a bonnet to wear, whether to put on heavy or light underclothes, or whether it is to be a rain coat or one for warmth. It falls to the lot of few men to be called upon daily, before breakfast, to advise many millions of people as to what they should do or wear for the day. That you do not all become vain and spoiled by the adulation or execration and the universal daily and hourly attention which you get from millions of people is the best possible evidence that the civil service examination selects the right men.

There are, perhaps, a dozen people who, with me, have a different point of view of your work from that of the rest of mankind. We have to deal with the same element which mostly occupies your attention. We watch the records that you have carefully made for years to find where our field of action mostly lies. While you study the action of heat, cold, and electricity upon air masses, and what currents they are likely to produce, and what results are likely to come from those currents, we are largely interested in those currents themselves and what we can get out of them for mankind in general and for a few of the same kind in particular. While you note with great care the presence of a low, the direction of its movement, and the surrounding conditions, and foretell what is coming next, we are content to know that it exists and will surely raise the wind. What we loathe and detest is a stagnant and inactive condition of the atmosphere. We want something going on, and we would like it at about 15 to 18 miles an hour, but can do with it at about 10 miles an hour.

I am happy to report that there are very few days, indeed, in the course of the year in this region when we do not get the necessary air currents some time during the day, and I have no doubt that when your attention is properly called to these derelictions (seldom as they are in the vicinity of the "Cream City" or the "Windy City"), that defect will be remedied.

I doubt if the fact is fully realized that there is sufficient power which can be had for the taking, within 100 feet of the ground in a space 5 yards in diameter, to do all the work to be done on a 40-acre farm, from the sowing, cultivating, harvesting, thrashing, and marketing of the crops, to the rocking of the babies and the doing of all kinds of housework, and to furnish light, heat, and ice for the house, and electric light for the chickens to sleep by. It is certain that if the energy which passes through this space—5 yards in diameter and 100 feet high—were properly utilized in this region, the man who owns the 40-acre farm on which this ideal conservatory of wind energy is placed

might avoid any physical exertion in carrying on the task of farming, and living, and being. Each man so situated would simply be the engineer who directs the application of the energies which the heavens furnish free and distribute to every farm and locality with a hand at times even too lavish.

All that is required of us is to furnish the means of converting the energy which passes over this piece of ground into some form, such that it can be stored, transported, and readily used. The unfortunate thing is that this energy, now being wasted, is somewhat shifty in its behavior, and rather diffuse and dilute. The energy utilized at Niagara Falls is not more sure in its annual quantity than the energy which wastes itself over the Dakota farm. The Niagara energy, however, exerts itself in one direction the year through, is very much condensed, and stable in quality and quantity from day to day. On the other hand, the energy to be derived from the winds at a given velocity varies with the pressure, the temperature, and other conditions of air, and varies in intensity from nothing to 100 miles an hour in succeeding minutes. But when the coal fields are gone, and the forests are burned up, and the oil fields are pumped out, there will always remain this universal force distributed almost everywhere on the face of the earth, which can be utilized for almost every known human need which physical energy can supply. The records which you are making to-day will, I have no doubt, contribute very greatly to this end. Either storage of compressed air, or the production of liquified air, or the storage of electricity will probably, in the near future, be largely employed to utilize wind power for many human needs, in addition to the countless uses already being made of these energies. By common consent the study and records pertaining to this universal source of energy have been left to you. You are, for the time being, the custodians of this great bounty to mankind.

The Agricultural Department has done wisely to publish investigations and records of actual tests of actual work being done in the field. The future will look to you for the final records, statistics, and information which will speed the day of almost universal use of wind power in the home, field, and farm, and for many larger services remote from the more reliable sources of energy. Much eloquence has been heard about "harnessing the lightnings of the sky," but here, gentlemen, in the subject of your study is a force at all our doors with which man can make the lightning at will and to order.

"The winds of heaven" are clearly what the future man will harness as his universal beast of burden.

Professor MOORE. Most of you gentlemen have had the pleasure of becoming well acquainted with Mr. E. R. Sharwood, the secretary of the Maritime Association of Philadelphia. He has been a member and an officer of that important organization now for twenty-five years, nearly as long as this Weather Service has been in existence, and he has always been a staunch supporter of the Weather Service.

Mr. SHARWOOD. As I sat and listened to the graceful flow of language of Professor Moore it seemed to me very easy to get up and say something on a subject so interesting to me, but when I learned that there was a gentleman present taking down what was said the thoughts I had took flight, and are now but a misty vision, like one of Professor McAdie's fog banks out over Lake Michigan. I shall not therefore undertake to rival the rhetoric of my good friend Professor Moore, but shall confine myself to one or two references to the Weather Bureau in its relations to commerce.

I am here by the invitation of Professor Moore, as a commercial representative of Philadelphia and as an officer of one of its commercial organizations, the Philadelphia Maritime Exchange. It has been the policy of this exchange for many years to identify itself as much as possible with those departments of the National Government which are more or less closely allied to commerce, notably the Light-House Board, Life-Saving Service, Coast and Geodetic Survey, Hydrographic Office, the Engineer Corps in its relations to harbor and river improvements, Bureau of Navigation, Marine-Hospital Service, and last, but by no means least, the United States Weather Bureau. It has been my privilege as an executive officer of our exchange to frequently meet with the heads of these departments, and my duties have been very much lightened and made very agreeable in consequence.

My first recollections of the Weather Service carries me back to the centennial year. In looking around me after I had been installed as secretary of the Maritime Exchange I was asked one day by a friend to visit the signal officer of the United States Army stationed in Philadelphia. I did not know what a signal officer was, but I went with him and was introduced to Sergeant Beale, whom some of you doubtless remember. He was a man of interesting personality, and I there and then received my first ideas of the work he was performing for the Government and commerce. Shortly after this, in the course of my duties, I visited Cape May, and there I found a gentleman, then representing the Signal Service, who is with us to-day, Sergeant Townsend. [Applause.] It is evidently not necessary for me to introduce you to Sergeant Townsend. I will only add that he and I exchanged confidences in 1876, and I now know him well and respect him highly.

The Weather Service has made rapid strides and stands to-day a monument to its builders. It would not be possible for me to speak of the scientific work of the Bureau, for I am not a scientist, but I can testify to the painstaking efforts of its officials, both in Washington and at stations I have visited, in placing at the disposal of commercial interests the material gathered through its very admirable system. The value of the Weather Bureau to the commercial and maritime interests of this country is hard to calculate. Storm warnings, and especially West Indian reports during the hurricane season, are of great interest, and it was my privilege at the last session of Congress to prepare a memorial setting forth the advantage to commerce of these reports, urging a liberal appropriation for their continuance.

In connection with the work of the Weather Bureau, I recently made an appeal to your chief to try and bring the service into closer relationship with the commercial interests of Philadelphia. Our fine Bourse building had been erected within a few years and all the commercial and maritime bodies had located themselves in this building. The Weather Bureau was situated in the Government post-office building, on the upper floor, far enough away from the commercial interests to cause the observer to look up in surprise when he received a visitor. Of course the Bureau occupied offices in this Government building rent free.

After discussing the matter with your practical chief, and after he had personally visited the Bourse building, it was arranged that the management would furnish free of charge space on the main floor and make electrical connections with the instruments on the roof and maintain the same if the Bureau would make an interesting display. This arrangement was soon carried out, with the result that

we have to-day on the floor of the Philadelphia Bourse as interesting an exhibition of the possibilities of the United States Weather Bureau as it is possible to make. The commercial public have taken the matter up with zeal, and the daily visitors to the exhibit are on the increase. After the exhibit was installed Professor Moore was kind enough to detail Mr. Townsend to take charge of it, and instructed him to be on hand daily between the hours of 10 a. m. and 2 p. m., to follow up the good work and reply to the multitude of questions that of necessity would be put to him.

Classes from our various colleges and schools have visited the Bourse Weather Bureau exhibit, and it is the consensus of opinion that the Weather Bureau and the commercial and maritime interests of our city are closer together than ever before, and I feel sure from the remarks that I have heard expressed by prominent men that the interest will continue.

I have nothing more to add. It has been my privilege for a long time to enjoy the friendship of Professor Moore, and I feel sure that his energy and perception, fortified by his able staff, will find other outlets, and further cement friendly relations with the maritime and commercial interests of our country.

Professor MOORE. The Rev. Father Odenbach has shown great interest in our convention; he has been in attendance at all its sessions and his presence and his participation in our labors are greatly appreciated by every member of this gathering. We should be greatly pleased to hear further from him this morning,

Father ODENBACH. I have been waiting for this chance to speak to you, for on an occasion like this I have volumes to say. Still, to control the time as well as my own feelings, which might carry me away, my words will be few, but my heart will be in each and every one of them.

How do others see you? That is the question you ask me, and I will tell you how men of penetration, unselfish men, men who know you as I do, regard you. Let me voice their sentiments and render this judgment: Gentlemen, I find the members of the Weather Bureau to be men of a superior stamp as to intellect, as to interest, as to their fidelity to duty, and, above all, as to their great charity to an often unappreciative public. During these days of the convention I have been repeatedly tempted to pride at the thought that I have had the privilege, the honor, and the good fortune to meet with a body of men that reminds me so very much of the body to which I have the honor to belong. Gentlemen, I am a Jesuit, and I am proud of it; and here among you I find in this convention of Weather Bureau men that same earnestness of purpose, that same rigid discipline, that same self-sacrifice to duty to which I have been educated and by which I have been surrounded for almost twenty years. I have found this spirit in no other third instance either on this or the other side of the great waters.

This, gentlemen, is the impression I have of the Weather Bureau man as I have had the pleasure to meet him. From the chief down to the last boy in the service; from the man who lost his health and impaired his senses in sending a distress message on the Atlantic coast in a cold winter night down to the latest hero in the service who risked his life in the midst of a blast that carried off the barograph, so valuable to the service; these gentlemen, taking them for all in all, are men, and "who dares be more, is none." This must also be the verdict of all who know you as I know you; of all who

know you enough to form a competent judgment. As to the rest, do as you please. The saying of nature's poet should be written over the entrance to every Weather Bureau office:

> The evil that men do lives after them; the good is oft interred with their bones.

Write it there; write it in glowing letters. You can make use of it; you can apply it every hour of the day. [Applause.]

Professor MOORE. There is one very important part of our work that has lately become prominent before the people, and that is the dissemination of our forecasts. There is no use in collecting information if you can't distribute it; no use in having forecasts of cold waves if you can not give them to the people that have property to be injured by cold waves. The press is our great medium of dissemination; but there are thousands of people who are out of reach of the press, and so there has grown up through the energy of the Post-Office Department a system of distribution to rural communities, and the man who originated that system and who is putting it into effect—the superintendent of the rural free delivery—has just entered this room. He has taken great interest in the distribution of the morning forecasts by his special carriers, and is furthering our work in that direction to the greatest degree possible. In fact, I am inclined to think that the Post-Office Department is the leader, and that whatever credit comes from it belongs mainly to the Post-Office Department rather than to the Weather Bureau. We are more in the position of simply cooperating by giving the forecasts than of being the leaders. We wish the credit to be where it belongs—with the Post-Office Department, and to a great extent to Mr. Machen himself. We want to hear from him.

Mr. A. W. MACHEN. After receiving your very kind and pressing invitation to be present at this gathering, I feel somewhat ashamed to come in at the eleventh hour. But the new service with which I am connected so engrosses the time of all those engaged in its management that it is scarcely possible for any one of us to leave his desk at Washington. The employees of the rural free-delivery division may be found early and late preparing the data upon which rural routes are being established at the rate of 30 a day.

I take it, from what I have learned from Professor Moore in several conversations I have had with him on this subject, that you are anxious to hear all about the rural free delivery service and to learn to what extent it may be used as a medium through which to scatter throughout rural districts the valuable information gathered daily by the United States Weather Bureau.

I doubt if the representative of the United States Post-Office Department at the Vienna convention of the Universal Postal Union in 1891 for one moment dreamed that within ten years the agreement signed at that time (and in honor of the United States, on the 4th day of July, 1891) would be so nearly fulfilled in this country. It was agreed then that as soon as possible all of the postal administrations which were members of the Universal Postal Union would establish a house delivery not only in cities and towns, but also throughout rural districts. Postmaster-General Wanamaker realized that the vast extent of territory of this country, much of which is sparsely settled, made the question of a house delivery difficult to handle, much more so than it would be in a small country with dense population and good roads. He therefore decided that thorough experiment should precede an attempt at universal free delivery. Congress was asked to appropriate $10,000 for this purpose. An

appropriation of $10,000 was granted in 1892, available July 1, 1893. I had the honor to be superintendent of free delivery at that time and was ready to begin an experiment; but with declining revenues and increasing deficits confronting him, the Postmaster-General was loath to take any step that might further involve the Department and entail upon its future revenues what he thought would be too great a burden. The appropriation was not used, and so it was with the appropriations for the three succeeding years. In 1896 Congress included in the appropriation of $40,000 a mandatory clause. Prior to that time the use of the appropriation was optional with the Postmaster-General. In October, 1896, Postmaster-General Wilson ordered that steps be taken to carry out the wishes of Congress. The first route was established at Charlestown, W. Va., October 15, 1896, with many misgivings as to the success of the experiment. On the 1st of July, 1897, 43 routes were in operation. Congress then increased the appropriation to $50,000, and the new administration of affairs, seeing the great possibilities of the rural service and the benefits its introduction would bring the farmers of this country, ordered that every dollar of the $50,000 should be expended in broadening the experiment.

The following year the sum of $150,000 was provided, followed by $300,000 for 1899, to which a special deficiency of $150,000 was added, making a total of $450,000 for that year. Three hundred and ninety-one routes were in operation July 1, 1899; in 1900 there were about 1,200 routes. During the past fiscal year we established 3,100 routes, so that on July 1 we had 4,300 in operation, and by September 1 next (1901) 5,000 rural carriers will be delivering mail to 3,500,000 people in rural communities.

You who are engaged in a service in which experiments must be made from time to time can well understand with what the Post-Office Department had to contend at first. We knew not just what to do. I remember well when I asked the Postmaster-General to detail ten of the best inspectors in the service to come to my office and discuss matters with me before starting out to establish the first routes at points designated by the Department. When that meeting was called no one knew what to say. We wanted to establish rural free delivery. The first question asked me I could not answer, for the reason that I had had no experience myself in country delivery. How many families should be served on each route, how long should the route be, should all roads be traversed, what should constitute a reasonable day's work for the carrier, what salary should carriers be paid, what amount of bond should be required, and many others were the questions asked, to which the answers were nothing less than mere guesses. Everything about the new service had to be worked out gradually—evolved, so to speak. Four years ago it was in embryo; to-day it is a bouncing boy, growing into youth and manhood, soon to become the sturdy giant of the postal service.

You will understand, gentlemen, that with a constant clamor for this service from 250 Congressional districts it has tested the ability of the Department to the utmost to make a distribution of routes among districts and States to the satisfaction of all who have petitioned for them. Necessarily the service became scattered, and in its early days there was not a sufficient number of routes clustered in one locality to enable the Department to obtain results upon which to base a satisfactory report to Congress. Postmaster-General Smith was the first to foresee the necessity of a concentration of service, and in 1899

ordered the establishment of the first complete system of rural free delivery; that is to say, a service covering a whole county and displacing the old system of fourth-class post-offices and star routes. That county is well known to-day throughout the United States, especially by those who want the same kind of service—Carroll County, Md. This county has an area of 453 square miles, with a population of about 35,000, and to-day 45 rural letter carriers are delivering mail to between 7,000 and 8,000 farm families every day, and 90 per cent of it before 9 o'clock in the morning, for they leave Westminster and other distributing points at 6.30 a. m. The service displaced 66 post-offices and all the star routes in the county, numbering 33. The first quarter's results show that the saving caused by the discontinuance of post-offices and star routes, plus the increase in revenues actually accruing after the introduction of the service, came within $300 of paying the cost of the rural free-delivery service.

In Carroll County there are four traveling post-office routes. These differ from the ordinary rural routes in that they supply other routes with mail. The postal wagons, as they are officially known, are traveling post-offices in the full sense of the term, performing all the functions and providing all the facilities of post-offices, such as issuing and paying money orders, registering letters, selling stamps, etc.; in short, they are a post-office divided into four parts, hauled around through the country for the accommodation of the people. Last year the four wagons did a business equal to that of a Presidential post-office yielding a revenue of $4,000 per annum.

The county service will come gradually; we can not extend it as rapidly as we would like. In the county service alone do we see the perfect system of rural free delivery. Since the establishment of the Carroll County service we have established the service in half a dozen counties. It will soon be established in Delaware County, Ind., also in a county in this State (Wisconsin), one in Iowa, and one in Missouri. There is now one each in Pennsylvania, Tennessee, and Connecticut, and Niagara County, N. Y., will soon be completed. In the county service the amount of mail handled increases at once from 50 to 100 per cent, and the amount of mail collected from a route increases from 20 to 25 per cent. Remember that the collections from rural delivery routes mean a good deal more to the service, relatively speaking, than the collections in the large cities, because the farmer sends practically nothing but first-class matter—letters and postal cards; he sends no circulars, nor does he mail newspapers at the rate of a cent a pound, so that 95 per cent of the pieces of mail collected on a rural route bear 2-cent stamps, and it is the 2-cent stamp that makes up the great bulk of this country's postal revenues. Ninety per cent of the $111,000,000 produced last year comes from the sale of 1 and 2 cent stamps; so when I tell you the collection of this class of mail from the farmers in this country increases 25 per cent immediately after the establishment of rural free delivery, you can easily see that free delivery is bound to become a great factor in the increase of the postal revenues, and thus eventually become self-sustaining. To illustrate, let me relate what a well-to-do farmer of Carroll County told me when I expressed my belief that rural free delivery would be a great revenue producer. "Your statement," said he, "is not surprising to me. Before you established rural free delivery my postage bill amounted to $2 or $3 a year. Now every time the rural wagon comes over the hill my boys and girls think they ought to have a letter for it, and my postage bill is $2 or $3 a month."

This is practically true of many of the patrons of rural free delivery in other parts of the country.

To what extent can rural free delivery be used to distribute weather forecasts is a question which no doubt deeply interests all weather forecasters. Just before leaving Washington I had placed before me a statement showing the number of offices at which the Weather Service could now be handled by rural carriers. About a month ago a general letter of inquiry was sent to postmasters at rural free delivery offices, about 2,600. Replies have been received from about 1,800. Of the 1,800 points there are 464 which the carriers leave at 10 o'clock or later for their routes, so that it will be possible at these offices to use the rural carriers to distribute forecasts as soon as the Weather Bureau can arrange to get the information to the postmasters, who will be authorized to stamp the cards. Four hundred and sixty-four out of 1,800 is about 25 per cent. On the 1st of October there will be 3,000 points in this country served by rural free delivery. At the same percentage it is seen that 750 offices may be reached by the weather forecast system after that date. Averaging two carriers to the office means 1,500 carriers, who could deliver forecast cards to about 150,000 farm families. That will make a pretty fair start. There are a number of other places at which, upon investigation, we may be able to detain the carrier until after 10 o'clock.

The motto of the rural service is "Prompt delivery and quick dispatch." The mail must be given first consideration. It must be gotten out as quickly as possible, and by all means collections must be returned to the office in time for dispatch the same day. When the principal dispatch of the day is early in the afternoon, the carrier must leave early in the morning—too early for the forecast. In such cases, of course, rural free delivery can not be of assistance to the Weather Bureau.

Another question: Could not the rural carrier carry some kind of a weather signal? Your chief has suggested to the Department a system of displays on the side of the rural wagon. It is doubtful if such a system could be applied at this time. Rural carriers are not yet required to provide uniform wagons. Some use uncovered carts, some use buggies, and some of the more progressive buy well-made rural mail wagons. Of course under these conditions, with different styles of vehicles, a uniform display device could not be handled. But I see no reason why a rural carrier should not carry a flag signal or pennant. This, I think, would prove more efficient than a display device on the side of the wagon, because it could be seen at a distance. Farmers in the field would know at a glance what the weather probabilities were. I am speaking with full authority from the Postmaster-General, who takes more interest in this particular branch of the service than in any other, when I say that he wishes anything and everything done by which the rural free-delivery service may be made as nearly as possible a perfect convenience to the farmers of this country. He is therefore in full sympathy with any movement looking toward a complete cooperation between the rural free-delivery service and the Weather Bureau. He will authorize any rule or policy looking to that end, for under the appropriation act providing for rural free delivery he is given the greatest latitude and may promulgate any regulation that does not conflict with the fundamental postal laws.

By the exercise of this great discretion he allows rural carriers to become news agents and to sell newspapers on their own account to

the people on their routes, so long as the papers have passed through the mails. Hence it is that the carriers are also allowed to peform private commissions for the people. While they must not act as agents for corporations, express companies, department stores, and the like, they are not denied the privilege of doing little errands for their patrons, so long as such work does not interfere with their official duties.

So you see, my friends, that with the heads of the two great Departments, the honorable Secretary of Agriculture and the Postmaster-General, working in perfect accord to a common end there can be no failure. The successful use of the rural free-delivery service as a medium for the distribution of weather forecasts is, I think, assured. It only remains for the Weather Bureau and the free-delivery system of the Post-Office Department to work out the details, and, judging from the earnestness which Professor Moore has already displayed in this matter, there will be no trouble whatever in perfecting a system by which not only the rural free-delivery service itself will become more popular, but your service will be made more far-reaching and beneficial to the people.

Every telling postal improvement marks an era in the history of the postal service. The introduction of the stamp in the early forties, the fixing of a uniform rate of postage in 1851, the inauguration of the registry system in 1855, of the free delivery in cities in 1863, the adoption of the postal money-order system in 1867—all were great strides in the march of progress during the past sixty years; but none of these is as far-reaching, as important, or as satisfactory to the people as the latest departure, the rural free-delivery service. The other features of the service are great conveniences indeed, but to make use of them, to be benefited by them, people must go to the post-office. The rural free-delivery service differs from them in that it goes to the people, and carries with it all the other facilities of the post-office, for, besides delivering and collecting ordinary mail, does not the rural carrier register letters en route, receive money for money orders, sell stamps and stamped envelopes, and, not least of all, deliver the daily forecasts supplied by the Weather Bureau? In short, is he not a traveling post-office?

Since the demonstration of the success of the rural free delivery I have often wondered why this great country discriminated against the rural communities as long as it did, and I am inclined to take some stock in the statements, made forty years ago by the opponents of city delivery, that the law limiting that service to cities of 10,000 inhabitants and over was nothing more nor less than class legislation. To what extent our farmer friend has been discriminated against may best be demonstrated by following a letter from the time it leaves the farmer's hands in Wisconsin until it reaches the merchant in New York, and the reply as it leaves New York and eventually reaches the farmer. After putting off writing for several days, on account of fatigue, the farmer finally writes his letter, hitches up the old gray mare, that has probably worked all day in the plow or the mowing machine, and drives 5, 6 or 10 miles to the nearest post-office, where he deposits his letter. From that point it is taken by star route to the railroad office, where it is put aboard the postal car. At Chicago it catches the flying mail for New York. When this train reaches Albany a corps of experienced distributers board it, and make a distribution of the mail for New York City by stations. The mail is received at New York, sent to the respective stations, and our farmer's

letter is hurried to its destination. It has from six to nine chances of delivery during the day, for the carriers in that city make from six to nine deliveries each day. It is delivered to the very desk of the addressee, is promptly answered, and the reply carried by the office boy to the nearest mail box, where it has thirty-two chances every day to be taken up by the collection service. It soon finds its way into the New York and Chicago railway post-office, reaches Chicago, and is sent out to the village for which it is intended. In many instances the train does not stop and the pouch is thrown off. If it is not drawn under the train and ground to pieces, the letter will reach the post-office, where it remains until the farmer calls for it. No letter carrier is there to hurry it out to the farmer; it must await some one from the farm. He may come in a week, or, if it is harvesting time, the busy season of the farmer, probably two weeks. Napoleon used to say that if allowed to lie long enough a letter would answer itself. Many a letter addressed to the farmer has answered itself, or in other words, has gone unanswered. All this has been changed by rural free delivery. The letter box erected along the rural route is a standing invitation to the farmer to write letters. He accepts the invitation; he does not hesitate to write, even though he is fatigued, because he knows the letter will be called for at the farm gate, and its answer eventually delivered to him at the same spot. Increased facilities bring increased business. The truth of this axiom has been fully demonstrated within the past two or three years by the rural free-delivery service. Collections from rural routes, as I have stated, increase from 25 to 40 per cent, showing that the rural communities are quick to take advantage of the facilities extended to them by the service.

Rural free delivery is the greatest boon ever vouchsafed the farmers of this country. It places them in touch with the outside world, keeps them posted on current events, causes improvement of roads, enhances the value of the farm and farm products, and takes away from farm life the monotony and social isolation which is largely responsible for the desertion of the farm by young men who seek the excitement of our large cities. Rural free delivery, in short, is the city reaching out and clasping hands with the country, and bringing her country cousins into a closer and more satisfactory relationship.

Rural free delivery is no longer an experiment. Although it is only four years old it has already become an assured, permanent, and expanding branch of the postal system, and it is only a question of time and executive celerity until all the people may have their mail service at their very doorsteps.

There is no doubt in my mind that eventually rural free delivery will solve the question of good roads. Good roads are indispensable to an efficient rural service. This was brought forcibly to the attention of the Department last winter, when it became necessary to suspend the service on a number of routes on account of the impassable condition of the roads. While the actual number of suspensions of the service was, comparatively speaking, quite small, there was a large number of cases in which the service was performed with great difficulty and much delay. The rural carrier can not possibly make regular time and perform efficient service over poor roads, particularly during the winter and spring months. Recent official inquiries disclose the fact that a portion of the roads of at least 1,000 of the 4,300 routes in operation July 1 require some repairs. The Department is now advising road supervisors and other interested officials

that the lack of care given to the roads covered by rural routes will, if continued, endanger the permanency of the service, and it is the hope of the Department that a great number of the roads will be repaired before winter weather sets in.

One can not speak of rural free delivery without mentioning one whose name will be forever indissolubly connected with that service, for to Postmaster-General Charles Emory Smith is due the credit of bringing this new feature of our postal system out of the stage of experiment and uncertainty within a very brief period, and placing it on a permanent and most satisfactory basis. He has given this branch of the service more than any other his very best thought and attention; he has been equal to every emergency, and cutting away the red tape that too often impedes official action, has insisted that promptness, speed, and efficiency should characterize the introduction of the rural free-delivery service. Although the details of the service are intrusted to his subordinates, Postmaster-General Smith is at the helm, his is the guiding hand in the whole undertaking. The popularity and efficiency of the rural free-delivery service to-day prove the efficacy of his plans.

I can not close this somewhat rambling talk without referring to the very generous treatment given the rural free-delivery service in the Agricultural Department's Yearbook, and to assure the honorable Secretary and his associates that it is greatly appreciated by the Post-Office Department, an assurance his colleague, the Postmaster-General, has doubtless given him ere this. The great advertising which the Agricultural Department has thus given the service will, I know, be felt by my office when the greatly increased number of applications come pouring in as a result.

To Professor Moore and his associates in the Weather Bureau I wish godspeed in the great work in which they are engaged, and to assure them that the Post-Office Department stands ready to cooperate with them to the fullest extent to advance a service which carries with it such great benefits to the people.

Professor MOORE. It might be well to note that the director of our Maryland service reports that he gets his mail reports from Carroll County quicker and more uniformly than from any other county in the State.

We have heard several times from our good friend from Philadelphia, but we shall not regret, I know, hearing one word more from him before this convention closes. I call upon Mr. Harvey M. Watts.

Mr. WATTS. I thought I was to be left off this morning, and I feel that all I would like to say would be "Amen!" to what Father Odenbach said, and add "In secula seculorum!" But last evening in the papers I was quoted in a slightly ungracious way, which may be misunderstood by many here. I was talking of the position of the scientific man and his smaller monetary return for his work as compared with people in commercial life. Then I cited this convention as a remarkable one, solely concerned for the work it may do, and with no other object for existence. There have been no committees here on "more pay and shorter hours." The convention indeed has been given over to planning such extra work and investigations, in addition to the regular duties, that it seems to me the Weather Bureau men will need a twenty-four hour day to accomplish the tasks they are setting themselves. That, I think, is true of no other department of the public service of the United States. There is another thing wherein this service differs from all other departments of the

public service. You are not, like other employees, kept away from the public. You are under daily criticism. The Army and Navy came before the public in 1898 after thirty years of innocuous desuetude, and have had nothing but quarrels ever since. Here is the Weather Bureau every day under criticism. I do not believe much in adages, but there are two adages that I find have been disproved by this convention. One is that familiarity breeds contempt. I have found that this is not the case. On the contrary, the more I know of Weather Bureau people the greater respect I have for them. The other adage is that ignorance is the mother of admiration. I have never believed that. It is the stepmother of admiration. The greater knowledge you have the more you admire. So I will say that the more I know of you, the more I admire as well as respect the splendid earnestness of the work going on all through the United States in connection with the Weather Bureau.

It has really been a very great pleasure to me to be here, and I speak from the heart in saying so.

Professor MOORE. We had with us this morning Mr. McCurdy, of Chicago, who is one of the best-informed men in regard to lake marine matters, and especially lake marine insurance, in the country. I regret that business of importance has required his unexpected return to Chicago, but I am informed that before he left he prepared a few remarks and requested Professor Cox to read them to the convention.

Professor COX. Mr. McCurdy has asked me to express to the convention the great pleasure and profit that he has derived from his meeting with us. He said that he would like to give a word of encouragement from the underwriters, who fully appreciate the importance of the Weather Bureau and who are desirous of cooperating in the work of saving life and property at sea. Before leaving for Chicago, Mr. McCurdy prepared the following brief remarks, which, with your permission, I will read:

No longer can we account for the diminution of disaster on the lakes by saying we do not have the old-fashioned storms of the times of our fathers, but rather that we have timely warning of the approach of heavy weather. and the prudent master of the present heeds these warnings and remains safely in port.

Disaster from stress of weather at one time on the Great Lakes caused 75 per cent of the loss, while to-day stress of weather damage has fallen to less than 25 per cent. and the principal cause of damage is confined to collisions, which nearly always occur during calm weather.

We may concede in the superior construction of the modern steel ship an ability to withstand an ordinary storm, but here again we find a class of property of high value. very profitable to the owners, which neither owner nor master cares to imperil by taking an unusal hazard, and these men are quick to grasp the importance of an intelligent service like the United States Weather Bureau, and are the firmest believers in its necessity. The sailor, whose life is one of toil and hardship, has a voice of thankfulness for the Government that maintains a department that makes life a little more worth living.

Mr. Prof. MCADIE. This has been such a happy convention that I do not want to even suggest the possibility of another, but I do wish you would come to San Francisco, if it be possible. I wish it so much that I will not ask you to come—the things that are nearest and dearest to you in this life had better come of their own accord—but if you do come, you do not know how much it will please us. I might tell you some pretty stories about the "wild and woolly West," but perhaps this little incident will do for many others. Last night at the Press Club one gentleman from the Cream City was telling me of the great things that are to be seen on the Pacific coast. For instance, he said they took him down to Santa Cruz and showed him the big trees, and if

there is anything on earth, he added, that you will lift your hat to, it is one of the big trees. They had told him down there that these trees were about 350 feet high and some 8,000 years old. Now, I do not know what may have brought about the transition, but he told me that the trees were 8,000 feet tall and three hundred years round, and the strangest thing was that, owing to the Milwaukee Press Club's hospitality, I was rather inclined to agree with him.

Mr. MURRAY (of Cincinnati) advocated the holding of the next convention in that city, saying that from the early work of Professor Abbe and the Cincinnati Chamber of Commerce there was a certain appropriateness in the Weather Bureau officials meeting in Cincinnati.

Professor MOORE. Gentlemen of the convention, we are honored this morning in having with us the Secretary of Agriculture, who has done so much to build up and extend the Weather Service. I want now to introduce to you Secretary Wilson, who will say a word to you.

Secretary WILSON. I am greatly pleased to meet you. There is no bureau in the Department of Agriculture in which I take more interest than I do in the Weather Bureau. It is a bureau that never rests content with its achievements; it must be different to-morrow from what it is to-day. It is a bureau that has no counterpart or likeness throughout the civilized world. It is an American institution that steps out along progressive lines for the purpose of doing good to Americans and American property. [Applause.] I need not attempt to flatter you, because Mr. Moore has been doing that, but I must say that I have looked in the faces of some bodies of gentlemen in my time, and I think this pleases me as much as any I have ever met. I may as well admit here in your presence that I am more exacting regarding your conduct than I am regarding the conduct of any other bureau in the Department. Anything done by a Weather Bureau man that tends to interfere with safety and progress can not be overlooked or forgiven. We may give a second chance to the man who steps aside in other bureaus, but the policy regarding you is remorseless, because the lives of our people and the property of our people are in your keeping, and you must be, as you are to-day, gentlemen of education and character. But I want to say, on the other side, that, being so exacting with the men of the Weather Bureau, I am anxious at all times for the advancement of the Bureau, and the advancement of each of you connected with it. Nothing gives me more pleasure than to be able to do something to gratify a Weather Bureau man and show him that it is the intention of the Administration of President McKinley, who looks so carefully into the details of everything (and people never know about it), whose eye never closes when the good of the United States Government is to be considered, to reward merit. I am glad you are making such progress. The time is coming when the American forecaster will go around the world; the time is coming when we will send a message every morning to every producer and tell him what we know about the weather, and when we will send a message after every ship that flies the American flag and tell her what she is likely to meet during the day. [Applause.]

Professor MOORE. Gentlemen, this seems to complete our program. In closing this convention I wish to say that the one thing that impresses me more than any other is the feeling of good will and good-fellowship that prevails in this convention. Here are over 100 of the supervising officers of the Weather Service, each one in rigid competition with the others—for our service is one in which the "survival of the fittest" is the principle exemplified. Our object is

the welfare of the whole, not the welfare of the individual. It is the betterment of the service we aim at, and how to make this Bureau of greater and greater use to the people and more satisfactory to our Secretary, rather than individual preferment. Under such a system you are at all times in competition the one with the other. Nothing has done more to raise the standard and tone of this convention than the system of examinations that our Secretary has authorized me to put into effect. But notwithstanding this competition, which is really one of emulation as to who can best serve, I know of no factions in this convention. I know of no strife, except that of honorable emulation—that emulation which shall make the Weather Service still better and more useful to the American farmer and the mariner. This to me is one of the most pleasant things in regard to this convention. Not a man here has spoken a word against another. There is good will; there is bonhomie in the air. You assume great responsibilities with salaries that, although they have been greatly increased by our Secretary, are still small. You are part of a system which, through many ramifications leads up to the Central Office, and from the Central Office of the Bureau on to the Secretary. At headquarters there is the same feeling of good-fellowship that prevails among you. It is pleasant to say that we dwell together in peace, for peace means efficiency. Where there is strife there is inefficiency, for energy is frittered away by useless contention.

I declare this convention closed.

INDEX.

[D=Discussion.]

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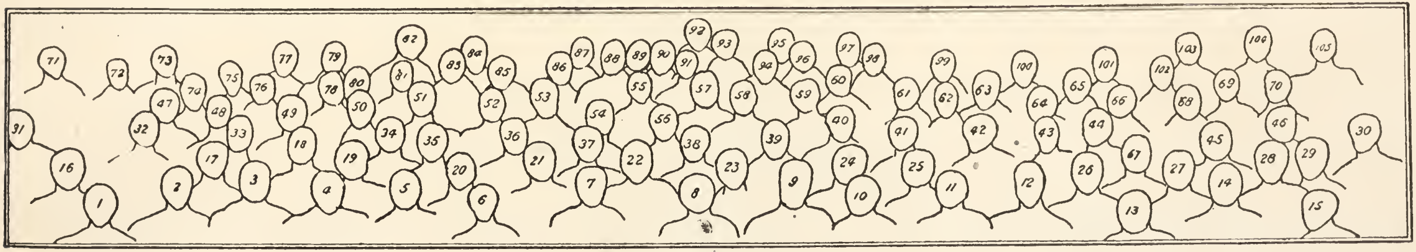
PLATE XXXVIII.

MEMBERS OF THE CONVENTION.



Key to Plate XXXVIII.

1 Mr. E. A. Evans, Richmond.
2 Mr. A. F. Sims, Albany.
3 Mr. T. F. Townsend, Philadelphia.
4 Mr. J. H. Robinson, Washington.
5 Mr. L. M. Pindell, Chattanooga.
6 Mr. O. D. Stewart, Grand Junction.
7 Prof. F. H. Bigelow, Washington.
8 Prof. Willis L. Moore, Washington.
9 Hon. James Wilson, Washington.
10 Prof. Cleveland Abbe, Washington.
11 Prof. C. F. Marvin, Washington.
12 Mr. W. T. Blythe, Indianapolis.
*13 Mr. A. W. Machen, Washington.
14 Dr. W. F. R. Phillips, Washington.
*15 Mr. La Verne W. Noyes, Chicago.
16 Mr. H. R. Patrick, Marquette.
17 Mr. J. S. Hazen, Springfield, Mo.
18 Mr. D. H. Carr, Milwaukee.
19 Mr. F. H. Brandenburg, Denver.
20 Mr. W. U. Simons, Key West.
21 Mr. R. M. Hardinge, Santa Fe.
22 Prof. H. J. Cox, Chicago.
23 Prof. A. J. Henry, Washington.
24 Prof. A. G. McAdie, San Francisco.
25 Prof. E. B. Garriott, Washington.
26 Mr. E. B. Calvert, Washington.
27 Mr. T. B. Jennings, Topeka.
28 Mr. E. W. McGann, New Brunswick.
29 Mr. James Kenealy, Cleveland.
*30 Rev. F. L. Odenbach, S. J., Cleveland.
31 Mr. J. H. Smith, Carson City.
32 Mr. E. H. Emery, New York.
33 Mr. L. S. Mosby, Ithaca.
34 Mr. W. S. Belden, Vicksburg.
35 Mr. H. E. Williams, Washington.
36 Mr. T. S. Outram, Minneapolis.
37 Mr. H. B. Boyer, Savannah.
38 Mr. L. M. Tarr, New Haven.
39 Mr. E. B. Richards, Little Rock.
40 Dr. I. M. Cline, New Orleans.
41 Mr. G. H. Noyes, Boston.
42 Mr. H. C. Bate, Nashville.
43 Mr. F. P. Chaffee, Montgomery.
44 Mr. P. H. Smyth, Cairo.
45 Mr. James Berry, Washington.
46 Dr. R. J. Hyatt, St. Louis.
47 Mr. A. B. Wollaber, Portland, Oreg.
48 Mr. A. McC. Ashley, Washington.
49 Mr. L. H. Murdoch, Salt Lake City.
50 Mr. L. G. Schultz, Fort Worth.
51 Mr. J. M. Sherrier, Davenport.
52 Mr. C. E. Linney, Chicago.
53 Mr. P. F. Lyons, St. Paul.
54 Mr. W. S. Palmer, Cheyenne.
55 Mr. O. W. Roberts, Yankton.
56 Mr. G. N. Salisbury, Seattle.
57 Mr. Al. Brand, Atlantic City.
58 Mr. M. E. Blystone, Springfield, Ill.
59 Mr. J. L. Cline, Sandusky.
60 Mr. E. H. Bowie, Galveston.
61 Dr. O. L. Fassig, Baltimore.
62 Mr. R. H. Dean, La Crosse.
63 Mr. E. J. Glass, Helena.
64 Mr. H. B. Hersey, Louisville.
65 Mr. B. L. Waldron, Columbus.
66 Mr. C. M. Strong, Oklahoma.
67 Mr. H. W. Richardson, Duluth.
68 Mr. B. H. Bronson, Bismarck.
69 Mr. S. C. Emery, Memphis.
70 Mr. L. A. Denson, Meridian.
71 Mr. W. S. Currier, Toledo.
72 Mr. E. P. Jones, Portland, Me.
73 Mr. L. N. Jesunofsky, Charleston.
74 Mr. A. E. Hacket, Columbia, Mo.
75 Mr. J. W. Bauer, Columbia, S. C.
76 Mr. R. B. Harkness, Houghton.
77 Mr. F. H. Clarke, Scranton.
78 Mr. E. C. Easton, Baltimore.
79 Mr. W. M. Fulton, Knoxville.
80 Mr. R. M. Reese, Washington.
*81 Mr. H. M. Watts, Philadelphia.
*82 Mr. E. R. Sharwood, Philadelphia.
83 Mr. George Reeder, Corpus Christi.
*84 Mr. C. B. Murray, Cincinnati.
85 Mr. C. F. Schneider, Lansing.
86 Mr. U. G. Purssell, Sioux City.
*87 Mr. B. W. Snow, Chicago.
88 Dr. W. M. Wilson, Milwaukee.
89 Mr. S. W. Glenn, Huron.
90 Mr. G. A. Loveland, Lincoln.
91 Mr. G. B. Oberholzer, Charlotte.
92 Mr. L. A. Welsh, Omaha.
93 Mr. J. B. Marbury, Atlanta.
94 Mr. F. M. Cleaver, Washington.
95 Mr. N. B. Conger, Detroit.
96 Mr. D. Cuthbertson, Buffalo.
97 Mr. G. T. Todd, Dodge.
98 Mr. M. W. Hayes, Havana.
99 Mr. G. E. Franklin, Los Angeles.
100 Mr. F. W. Conrad, Green Bay.
101 Mr. J. Warren Smith, Columbus.
102 Mr. P. Connor, Kansas City.
103 Mr. W. M. Dudley, Mobile.
104 Mr. S. M. Blandford, Boise.
105 Mr. A. J. Mitchell, Jacksonville.

* Visitors to the convention.